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SUBJECT:

Some Tests on the Efficiency of Alternating Current Apparatus,

BY DR. LOUIS DUNCAN AND W. F. C. HASSON.

Catalogue of Membership.

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A paper read before the American Institute of Electrical Engineers, New York, March 18, 1890, and discussion thereon. Vice-President Upton in the chair.

SOME TESTS ON THE EFFICIENCY OF ALTERNATING CURRENT APPARATUS.

BY DR. LOUIS DUNCAN AND MR. W. F. C. HASSON.

Several papers have appeared lately on the efficiency of alternating current transformers, some of which have been of a more or less theoretical nature, while others have given the results of actual tests. I have never, however, seen any tests on alternating current dynamos, excepting the experiments made by Dr. Hopkinson and Professor Adams on a de Meritens machine used for lighthouse work. Even the converter tests have given such varying results that one can hardly be certain as to the real efficiency.

The introduction of the alternating system has been so rapid and is so rapidly increasing that people are apparently well enough pleased with the results not to bother about the smaller question of the reasons for them. But whatever the results may be, it is of value to know just where the losses in any system may come in, so that we may seek how to avoid them; if we are succeeding, it may enable us to increase the profits,—if we are losing, it may help us to avoid further loss.

The apparatus, the measurement of which is the main subject of this paper, consisted of a Westinghouse 750 light No. 1 dynamo, with a No. 2 exciter and an outfit of 40-light converters. This apparatus had been presented by the Westinghouse Electric Company to the Johns Hopkins University, and was tested a couple of months ago. The workmanship of the machines is excellent.

The plant consisted of a 75 h. p. Armington & Sims engine driving the dynamo and exciter through a Tatham transmission dynamometer. Engine, dynamometer and dynamos were firmly secured to heavy parallel timbers which served as a foundation. The converters were banked on a wooden framework at a distance

of some thirty yards from the dynamo, and their primaries were permanently secured to the dynamo circuit, a switch in the latter serving to cut them off when desired. The ammeter belonging to the plant was put in this circuit and was read when efficiency measurements were being taken. The secondaries of the converters were taken to a switch-board and then to incandescent lamps mounted on racks.

Power measurements.—The Armington & Sims engine supplying the power worked regularly and satisfactorily and the governor could be adjusted to give the speed required at the dynamo. The Tatham dynamometer was the one used for power measurements at the Electrical Exhibition, held in Philadelphia, in 1884, where its accuracy was checked by making with it a de-

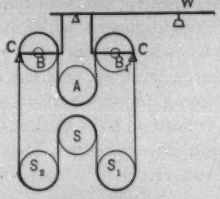

Fig. 1.

termination of the mechanical equivalent of heat. The result obtained in the latter measurement was 772.8 foot pounds per degree Fahr., and shows that the dynamometer is practically accurate. A description of the experiments and of the instrument may be found in the report of the test made to the Franklin Institute, but it will not be out of place to briefly describe the apparatus here.

An endless belt, as shown in Fig. 1, passes over the driven pulley, S, to the shaft of which the engine is belted, round the pulleys S_2 and B, to the driving pulley A, and back over B_1 and S_1 to S, again. The bearings of the pulleys B and B_1 are in cradles pivoted on knife edges, C, at their outer ends, and at the inner ends are connected by links at equal distances on the two sides of a knife edge which supports the scale beam W. The outer side of the belt passes through the line of the knife edges, C, and therefore has no effect on the scale beam, but the tensions of the inner parts of the belt act directly on the scale beam, and as they are on opposite sides of the fulcrum they act against one another. The beam is so graduated that this difference of tension is read

off directly in pounds, and this quantity—the difference of tension of the belt on the two sides of A—multiplied by its circumference and speed, gives the horse-power delivered. A weight travels on the beam, w, and readings can be taken with great accuracy.

Electrical measurements.—The energy in the secondary circuit was measured by means of a Cardew voltmeter and a Thomson ampere balance. As it is not the custom to put a number of secondaries in parallel, each converter had its separate lamp circuit.

Before making an efficiency test, the potential difference in the primary was regulated,—there being a Cardew voltmeter in that circuit,—and a separate measurement of the potential difference and current in each secondary circuit was made. When the test was actually in progress the voltmeter and ampere balance were used in one of the circuits and the currents and P. D.'s in the others were calculated from the readings in this circuit together with the previous measurements. Both the voltmeter and ampere balance were accurately calibrated, the former being checked after each test, while the latter had its constant determined with both continuous and alternating currents. The P. D. at the terminals of a non-inductive german-silver resistance in circuit with the balance was observed, when a continuous current was flowing, and also with an alternating current of the same period as that employed in the test. The current in each case was calculated from the resistance and P. D., and the results gave no appreciable difference in the constant for continuous and alternating currents.

The following tables show at once the order in which the tests were carried out and the results:

HORSE-POWER ABSORBED AT VARYING E. M. F.'s.

	E. M. F.		H. P
	Dynamo	Exciter	
Horse-power for exciter, field not made	0	0	.34
" " " field made	0	110	.75
" " dynamo alone	0		2.73
" " dynamo and exciter	0	0	3.04
" " " " "	0	107	3.51
" " " " "	1376	124	12.5
" " " " "	1168	104	10.1
" " " " "	1099	105	9.60
" " " " "	1040	105	9.0
" " primaries of converters on	1216	105	12.0
" " " " "	1171	104	11.8
" " " " "	1107	104	11.12
" " " " "	1048	104	10.64

TABLE OF EFFICIENCY AT VARYING LOADS

Approximate load.	Exciter.		Dynamo primary		Converters.		Horse-power in lamp circuit.	Mechanical horse-power.	Loss, in horse-power.	Efficiency
	E. M. F.	Current.	E. M. F.	Current.	E. M. F.	Current.				
¼	105	9.4	1107	10.	49.5	153.9	10.21	21.83	11.62	46.8%
½	104	10.5	1107	18.9	49 6	338.4	22.50	34.4	11.90	65.4%
¾	101	11	1113	28.6	50.0	520.7	34.9	48.0	13.1	72.7%
Full	119	11.5	1123	38.1	50.9	739.8	50.48	64.44	13.96	78.3%

EFFICIENCY OF CONVERTERS.

No. 8. 40-*light Converter.*

No. of lamps.	Volts	Watts in secondary.	Loss in watts.	Loss in iron	Efficiency.
40	50.0	2001	109	.....	94.8
0	50.9	0	84	84	.....

No. 4. 20-*light Converter.*

No. of Lamps	Volts.	Watts in secondary.	Loss in watts in secondary.	Loss in iron, watts.	Efficiency.
20	48.8	952	106.	95.2	90.0%
15	52.2	817	114.8	108.9	87 6%
10	50.3	506	101 7	99.2	83 3%
5	51.44	264	109.4	108 7	70.7%
0	52.3	0	110.5	110.5	0. %

The efficiency of the converters was measured by placing them in a metal calorimeter, between the double walls of which water was allowed to flow. The temperatures of exit and entrance were observed, as well as the weight of water which passed through; at the same time the current and P. D. in the secondary circuit of the converter were measured. A separate observation gave the radiation, which was of course allowed for, although it was made as small as possible. A number of converters were experimented on but I give but two of them; a 40-lighter, such as was used in the tests, and a 20-light converter which was very carefully tested by two of my students, Mesars. Bliss and McKeen. In the latter case the observations were made at slightly different P. D.'s, and the results show that the loss in the iron varies as we would expect it to vary, that is, very nearly as the square of the voltage. The variation will not be exact, as the losses due to the reversal of magnetism do not vary quite as fast as the square of the induction.

I would like here to call attention to the fact that in an excellent paper read before this Institute, Professor Ryan, of Cornell, found that the losses in the iron of a 10-light converter decreased greatly as the load increased. This was accounted for by the fact that there was a jar (evidenced by the singing of the converter) at the higher loads, due to the attractions of the secondary and primary coils. While it is true that the losses in the cores of very small converters are not exactly constant, yet they are nearly so, and a large part of the decrease found by Professor Ryan is due to the voltage being greater at the low than at the high loads.

Looking now at the figures given in the tables we are struck by two things; the very large amount of power absorbed in the core of the armature, and the very small loss in the converters

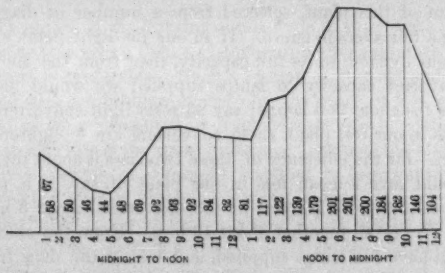

Fig. 2.

on open circuit. The dynamo losses due to reversals of magnetism and eddy currents, at the E. M. F. used in the test are no less than 6 h. p., while the energy due to reversal of magnetism and eddy currents in the 16 converters is only 1.6 h. p. Another rather striking thing is the almost constant ratio of primary and secondary currents over a considerable range. The maximum efficiency is about 78 per cent. It would seem that the losses could be divided into a constant part, and one varying with the current, but this is not true with the older style and smaller converters of the Westinghouse company.

Suppose we have a plant such as is described above, and use it for commercial lighting. Taking data from one of the local companies employed in supplying incandescent lights on this

system we have, for two 2,500 light dynamos, the following outfit of converters:—

Size of Converters.	Capacity.	Number in use.	Total Lamps.
No. 1.	5 16 c. p. lamps.	44	220
No. 2.	10 " "	61	610
No. 4.	20 " "	43	860
No. 6.	30 " "	49	1,470
No. 8.	40 " "	64	2,560
Total lamp capacity.....			5,720
Number of lamps supplied....			4,557

I understand that the converters being added are of the larger sizes.

The efficiency of the 30-light converters does not differ greatly from that of the 40 lighters. The accompanying Fig. 2, is a load diagram of this plant, selected from a number of diagrams as giving a fair average curve. If in our 750-light plant we are to work our dynamo to its full capacity, then from the above ratio of converter capacity to lamps supplied we would need converters for about 900 lamps; say 23 forty-light converters.

If, as in our test plant, these converters are 40-lighters, or 30-lighters—for the efficiency of these two sizes is about the same—we would have a mean loss in our plant of, say, 10 h. p. in our dynamos ($9.6 + C^2 R$), and in the converters about 3 h. p. ($2.3 + C^2 R$); or all together about 13 h. p. From the above table we will have 750 lamps supplied, and taking the data from the load curve the average lamp load would correspond to about 20 h. p., and the efficiency of the plant for 24 hours would be $\frac{11}{18} = 61$ per cent., minus the percentage of loss on the lines. This, in a properly installed system, should not average two per cent., so that the final efficiency would be 59 per cent.

A continuous current dynamo supplying the same outfit of lamps, with a maximum loss in the mains of, say, 15 per cent., would have a greater average efficiency. But I wish to point out that the maximum efficiency of the two plants would be about the same, so that they would require the same capacity of station outfit, boilers, engines, dynamos, etc. When more than one dynamo is provided, the efficiency of the alternating plant is increased by using only one of them during the times of minimum supply, and always working as far as possible only a little below the maximum capacity of the machines.

Let us consider these results in view of the present condition of incandescent light distribution in the United States. I take it that what may be called domestic electric lighting is largely a matter of the future—it is certainly not a matter of the present. The majority—the great majority—of the lights in use are in shops, saloons, theatres, offices, etc. Most of the lights wired are in use at one time or another during the 24 hours, and the proportion of energy supplied to the total capacity of the lamps connected is much greater than it would be in the case of house lighting, where, on the average, only a small fraction of the possible lamp-hours are actually in use. Under these circumstances the scheme of alternating current distribution is very different from what it will be when the attempt is made to supply an entire city with light, as they are attempting to supply London at the present time.

If the object of the lighting company is to supply the demand that exists at present, then a system employing a number of small converters is preferable. Such a system is flexible and can be installed with a minimum expense for the more or less scattered demand which is presented in even the most closely settled town. I take it that this is the great difference between the alternating and direct systems as at present installed in this country. The former skims over an extended district, taking advantage of its great flexibility to absorb any business which can be got; while the latter settles itself in a densely built centre, installs a larger plant than is primarily demanded, and works up a business within the limits of economical distribution. Therefore, it is hardly right to compare the present systems of direct and alternating supply, as the latter has not been reduced to a point where entire districts are to be supplied.

To show the disadvantage of the present system for domestic supply, suppose we have an ordinary house such as one of us would live in; it would be necessary to have a converter of at least 20 light capacity. The constant loss is, say, 100 watts; so, leaving out the $C^2 R$ loss, we would have a total loss in 24 hours, of $\frac{2400}{1800}$, or about 3 h. p. hours, corresponding to, say, 45 lamp hours. Taking my own experience the actual number of lamp hours used is about 30 lamp hours during 24 hours, so the efficiency of the converter would be something like $\frac{30}{75} = 40$ per cent. It is evident that unless the losses in converters can be greatly

decreased, a house-to-house distribution with a converter in each house would hardly pay.

It would seem, then, that when gas is to be displaced and serious competition with it is to be attempted a different system of distribution will be worked out. We must replace the numerous small converters with one large converter supplying a comparatively extended district, thus decreasing the total converter capacity since the law of average can be taken advantage of, and greatly increasing the efficiency. If an extended secondary network is employed, some of the converters may be disconnected from the mains at the time of minimum demand.

Let us inquire for a moment how the increase in the capacity of converters will modify the designs with which we are familiar. In the first place, if we increase the linear dimensions of any type, since the radiating surface only increases as the square while the volume increases as the cube of the dimension, then we cannot suffer the same loss per cubic centimeter of iron for the large as for the small sizes. We must decrease the intensity of magnetization or we must decrease the periodicity.

Let us take a typical case. Suppose we have a transformer and double all of its dimensions. If we employ the same induction we will need but one quarter the number of turns in the coils, and as the cross-section of the space occupied by the wire is four times as great, the area of the wire may be sixteen times as much. As the length is twice as great, the resistance in this case is one-eighth. But the losses in the iron are, roughly, eight times as great; this we cannot allow, since the radiating surface is but four times as great; hence we must diminish the induction. In fact we must so arrange things that the loss in the larger converter is only four times that in the smaller, in order to work at the same temperature. As at the low induction used the loss due to hysteresis varies nearly as the square of the induction, we may take it roughly that the large converter should have an induction of three-quarters of the smaller one. This will modify our figures. Instead of one-quarter the number of turns we will have one-third, and the resistance of the coils will be one-sixth instead of one eighth, as we can allow four times the loss that we suffered before, we can have, roughly, five times the output.

As a total result we have five times the output with four times the loss, or, as the $C^2 R$ effect is not important as compared with the other losses, we can have six times the output with the same

fall of potential in the secondary. That is, the efficiency of the larger converters will be greater than the smaller ones of the same design and working at the same temperature, but the output per pound of metal will be less.

Suppose when we increase the size we decrease the number of reversals. Take a case, for instance, in which the dimensions are doubled while the reversals are halved, the maximum induction remaining the same. We could have half the turns in the coils, and as they occupy four times the space and are twice as long, the total resistance would be one quarter, and for the same heating effect we would have four times the output.

If we consider losses due to eddy currents these will be constant per cubic centimeter, provided the period and maximum induction are constant and the thickness of the plates is unchanged; otherwise they will vary as the square of the induction, with a constant frequency, or inversely as the square of the period with a constant maximum induction. This in practice would make the values of the output for the larger currents given above somewhat greater. What I wish to show, however, is that we are limited by heating considerations and considerations of fall of potential in our secondary in the output of large converters. If we consider the properties of the materials of which converters are made we would, I think, find it most economical to make converters that reach the temperature limit, except for the very smallest sizes.

Many of us have, I suppose, read Mr. James Swinburne's paper read before the British Association at Newcastle last year on the "Design of Converters," and have been struck by the fact that almost all of the converter dimensions given by him are impracticable, either on account of the disproportionate heating of the larger sizes, or the excessive fall of potential in the secondary. In increasing the size of dynamos we usually increase the output per pound weight, but there is the vital distinction between dynamos and converters, that losses occur through the entire mass of the latter, and as we increase the volume we increase the losses in the same proportion. In the dynamo, on the contrary, there are practically no losses in the heaviest part of the apparatus, *i. e.*, the field magnets. As a result, while we gain in efficiency in the larger sizes, yet we must decrease either our induction or the rate of reversal, and the output per pound is lessened.

DISCUSSION.

THE CHAIRMAN (Vice-President Francis R. Upton):—Gentlemen, you have heard a paper that brings a new set of figures and measurements before the electrical world, and with such accuracy that they will probably stand as facts for certain constructions of apparatus. This paper, of course, brings up the broader questions—the questions of alternating and direct currents, and as far as their economical bearing is concerned, I think discussion directed to this point would be in order. We have Prof. Anthony with us to-night, and we should be pleased to hear from him.

PROF. ANTHONY:—I would prefer to wait and hear some of the others talk about this matter. Alternating currents I have never had anything to do with practically. There are people here to-night who have had to do with them and who know more about the results. I should be glad to hear from them.

MR. NIKOLA TESLA:—Dr. Duncan has brought forward some facts which have not been recognized before, for instance, the fact that the loss in the iron of the converter remains perfectly constant with varying loads. That has not heretofore been acknowledged or known so far as I have heard. But on the other hand, when we consider the action of the converter, I think it ought to be. In converters in which the primary and secondary are put in the closest possible relation, for instance, in the Westinghouse, the increase of the primary and secondary currents is in an almost constant ratio, and since the loss in the iron is due to something like a differential action of both currents, I think the loss of the iron ought to be constant within certain limits

With regard to the excessive loss in the dynamo machine—in the armature that Dr. Duncan has found, I think, that most of us know that this loss is not due to the fact that we must have that loss, but we must sacrifice a certain amount for the regulation of the machine. Now, the same machine that Dr. Duncan has tested any one of us could cause to give a greater output and with a loss in the armature of no more than one or two horsepower. But we must work with a highly saturated field, in order to obtain a constant potential on the converters. On the other hand, the comparison between the single circuit alternating current and the direct current machine is just, and the proportions I believe will be about as Dr. Duncan found them. That is, if we compare a single circuit alternating machine with a direct current machine we will find representing the output of the latter by a number—say by 100—that the alternate current machine with one circuit will give for the same speed and weight about 75, or perhaps less. But we must also consider that we are enabled with alternating current machines to work at a very much higher speed and the simplicity of the apparatus allows us to work with a very much higher electromotive force. On the other hand, if we operated an alternating machine with two circuits then the output of the machine will no longer be inferior

to the direct current machine but it will equal it, if not be greater. I believe that Prof. Anthony some time ago told me that he also found that the loss in the armature by higher field saturation increased more rapidly than we would generally suppose. I have found also if you take a large generator and saturate the field very highly we may by only a few revolutions in a few minutes heat the armature so that the wires will burn out. I think the losses in the armature increase very greatly with the saturation of the field. Now, as regards the general results obtained by Dr. Duncan, I am firmly convinced of their correctness, of course, but I also firmly believe that Dr. Duncan has not had the best converter in hand. For I have myself made tests, and others have made tests, where the efficiency of such converters is shown to be much higher than is shown by Dr. Duncan. With the improvements we have made lately I believe that the new converters have now reached a much higher efficiency.

MR. H WARD LEONARD:—We had some theoretical discussion relative to comparative efficiency of the continuous and alternating currents at Chicago a couple of years ago. At that time we had very little beside theory to work on, especially as regards our knowledge of anything in the alternating field. But I was a little interested in looking over the figures, which at that time were arrived at theoretically, and comparing them with those which have been obtained. The claim for the continuous current efficiency which was made there was based on a maximum loss of twenty volts on a three wire system, on each side, that is, fifteen per cent.; and the average load was considered as forty per cent. on that maximum. Therefore the average loss in the conductors was considered as six per cent. for twenty-four hours, that is, an average efficiency of ninety-four per cent. With the generators operated as they would be in such a system at full load by cutting off such generators as were not needed, assuming an efficiency for the conductor of ninety-four for the feeders, one per cent. average loss in the mains, one per cent. average in the service and inside wiring, brought the total efficiency of the continuous current system to a figure of 84.7. With the alternating current system the lowest efficiency that was assumed on account of the much higher figures that were claimed was 85 per cent. for the generator, 95 per cent. for the feeder, 90 per cent. for the converter, 99 per cent. for the service and inside wiring, which gave for the total efficiency 74 per cent. I was not fortunate enough to hear the actual efficiency which the present three-wire system showed; but I remember that the Professor gave the efficiency of the alternating as 61, instead of 74. I think that a point which is perhaps the most pertinent and which has been pretty well emphasized of late, is the fact that the average load of a system of lighting generally through a city is such a very small percentage of the connected devices. I know of one instance where the lighting has not yet reached the condition which it

will later as regards supplying a much larger connected load than it has at present, and yet the average load for 24 hours is only about 12 per cent. of the connected load. This, of course, brings into very forcible action the efficiency of devices which are low in efficiency under conditions of light load. In the case that I have mentioned the maximum load is 30 per cent. of the connected devices, and the average load is 40 per cent. of that maximum.

DR. WHEELER:—Although I may not be able to add anything to the subject of converters, I might say something about the effect of alternating currents with parallel wires. I know of a case in this city where lines ran parallel for about three miles, and where the current pumped up and down continuously, causing the lights to beat just as if they were driven by a steam engine which did not have a heavy enough fly wheel. After a very extensive investigation, it was found that the pumping of the lights was due to the fact that alternations on two circuits were nearly but not quite synchronous. When one set of waves caught up with the set of waves on the next wire while passing them they first drove those waves ahead and then drove them back. This caused the energy of one circuit to first pile up the energy in the other circuit, and then force it down, and thus cause a pumping effect on the lights. That was overcome entirely by placing the wires in pairs properly, that is to say, the two legs of each circuit had not been arranged side by side. One or two of the circuits had been misplaced. But by bringing those together, so that the negative side or "leg" of one circuit was right alongside of the other "leg" of its own circuit and not mixed up with the wires of any other circuit, the induction was completely neutralized, and that left the lights perfectly steady. This has nothing to do with converters, but is about the only thing that I can contribute to the subject. It was quite important. The lights pumped very badly. The company was very much troubled to know what the cause was. I had been formerly driving Edison dynamos with high speed engines and I laughed at the people who were running the lights, and assumed that their fly-wheel was not heavy enough. They suggested that I could go and try the fly-wheel. I made them buy a very expensive speed indicator and put it on, and about as soon as they got it running I made up my mind that the inertia of the indicator mechanism would be too great to allow it to respond quickly enough, that is to say, if the steam engine made about 74 revolutions a minute, as it did, and if its speed varied enough to show a flickering in the light, which would be about two per cent. variation in the middle of each stroke of the engine, it would not be easy to get a speed indicator needle which would show such brief, rapid and small variations as two per cent. variation on every stroke, that is, in less than one second for each. I then tried figuring out the weight of the fly-wheel and how much its speed ought to increase

or decrease between the strokes. Assuming the fly-wheel weighed 30 tons and had a diameter of 30 feet, and 500 horse-power was being drawn off by the belt continuously and was being put into the fly-wheel twice in every stroke by a brief impulse of the pitman with no source of power in the intervals, how much would the wheel slow down in the seventy-fourth of a second? In other words, how much would 500 horse-power slow down a 30 ton fly-wheel of 30 feet in diameter in the seventy-fourth of a second. About the time I made up my mind that this would be a long matter to figure out, I decided to try the plan of substitution, that is, to change all the elements of the system one after the other, until I found to which element—for example, the dynamo, the lines or the engine—the trouble was due. We therefore tried driving the different dynamos by different engines and connecting different lines on to different dynamos. We then found that the trouble went with a particular wire. That surprised me. I had gone so far in the matter then that I decided I was in honor bound to see it through. I went out and counted the number of pulsations in the lights and found that they were about eighty to the minute. I had inspections made and found there were only two parts of the city where the lights pumped in this way. I then immediately compared the pulsations of the other sets of lights and found they were 80 to the minute; the same as the first group. I then concluded there must be some reaction between the lines supplying the two districts. Following the wires out I found that the two sets of wires that supplied these two groups of light were placed in a position where they could act inductively on each other, while the others were so placed that they could neutralize their own effects, and I suggested that one set of wires be changed about. This was done and there was no more pumping. It was clearly due to one set of alternations "beating" with the set on the other wire.

MR. TESLA:—A point mentioned by Dr. Duncan was, how the construction of the converters would be modified when their size is increased. I had hoped that Dr. Duncan, whose work in that line has always been so valuable, would give us some points on that. It is evident to every one that it is impracticable to increase the size of the converter in the same proportion as its capacity is increased; because, as we operate the converter at a constant number of periods, we would render a long magnetic circuit transformer very inefficient. A plan was proposed by me a year or so ago to introduce this system in the construction of converters to have the same length of magnetic circuit, no matter whether the converter is large or small. I believe that this would be the proper way of constructing all converters on one system, and I believe that the present method of constructing converters is not right, for every different capacity of converter has a different length of magnetic circuit, and we know well that if one converter is adapted to, say 16,000 reversals,

another one with a different length of magnetic circuit is not adapted to the same number of reversals. We started a year ago, I think, to make all converters of the same length of magnetic circuit, so as to render them equally adaptable for the same number of alternations, no matter what their capacity is, and in such case, if we want, for instance, a converter that has ten times the capacity of a small twenty light converter, we will practically put in one converter so many multiple circuits as are required to get the capacity desired. We will allow a somewhat greater capacity to maintain the converters all at the same temperature.

I think that this plan should be followed. In general, I may say that the results obtained by Dr. Duncan refer to an apparatus a considerable time in use, but the advances that have been made in that line the last year only, are so enormous that we would not recognize this plan at all. For instance, I believe that the converters at present can be made to have less than half the leakage that they had previously In other words, it means practically you can run a converter with a double load—the machines are increased very nearly to double their capacity; and when we consider the short interval in which this has been accomplished, we may fairly assume that in a few years from now there will be little difference between the alternating and direct current, even on short distances. We will wait for that development in the meanwhile.

Dr Duncan:—In respect to the construction of converters, of course, in increasing the dimensions in the same proportion, I was not following out the proper design for every given converter. Every converter of a given design has its own proper dimensions, and all dimensions do not increase in the same ratio. But I think that Mr. Tesla's idea of keeping the same length of the magnetic circuit is hardly proper. I have worked out for my own amusement the design of a number of converters. For a converter of given capacity, there is a definite period which with the best proportions of iron and copper, corresponds with the maximum efficiency of the converter, but if you simply increase the cross section of the iron without increasing the length of the circuit you keep the same cross section of copper, which is not a good practice. You have to change both the copper and iron, and I did not think it would be very interesting to design a large number of converters for any given output. As for the efficiency of this plant which was tested, the plant was sent on, I think, in November, and was supposed to be the latest plant which was produced by the Westinghouse company. I have since heard that the efficiency of converters has been greatly increased. The losses in the converters could undoubtedly be greatly decreased, especially for larger sizes. As to the relative efficiency of the two plants, it must be remembered that I have simply taken a seven hundred and fifty light plant, and one dynamo is supposed to be always connected with the circuit. In a station of

ordinary capacity, that is of more than twice 750 lamps, we would certainly have the advantage of having at least two dynamos, one of which could be disconnected when the load had reached its minimum and the efficiency would therefore be greatly increased; and also in comparing efficiency of alternating and continuous plants, we must remember that the business that is catered to by these two systems is very different; that the load diagram of the alternating plant is very different from the load diagram of the continuous current plant. An alternating plant takes up the cream of the business, so to speak. It takes up business in which they get the maximum output for a given number of lamps wired, and in that way we must not calculate the efficiency of the alternating and continuous current plants at the same average load in comparing them. If so, we are favoring the continuous plant very much. With the alternating current plant it is simply a commercial question. If you can put into a continuous current station an alternating dynamo which will get business that will pay you, it is undoubtedly proper to put that dynamo in. In the same way if you have an alternating plant and it is so situated that you can run part of the service more economically with a continuous current, then put in a continuous current dynamo. But as the business stands at present a combination of the two plants is undoubtedly the most efficient in many cases.

Mr. O. T. Crosby:—I should like to ask if the advances reported are in the direction of increasing the efficiency of the converter at all loads, or only at some normal loads?

Mr. Tesla:—I said before, that the leakage was reduced to one-half, and I thought it was clear enough that that applied as well to the working of the converters on the full load as on the small load. When I speak of leakage I mean no load at all. But Dr. Duncan said just now—I thought he misunderstood me in regard to the construction of these converters—I proposed not to keep the length the same and vary the section simply, but to vary the section of the copper, at the same time varying the section of the iron. We have plates, for instance which contain so many multiple circuits. These plates are so made that the coils can be just as well put in as one single circuit transformer, a form of construction invented by Mr. Albert Schmidt of the Westinghouse company, and in this way we have practically a number of independent transformers, and the only diminution of the capacity of such transformers is that we have got a somewhat smaller surface. Then we may allow a little higher capacity for that diminished surface. That is all. I think that point is very clear; and there is no doubt at all that this contruction should be followed.

Mr. Fred'k Darlington:—There is one thing which I think merits attention in the discussion of this question, that is that one system uses the 50 volt lamp, and the other system is forced to use a 100 or 110 volt lamp, and that by the same skill of con-

struction of lamps and the same advance in the art of manufacturing lamps, the 50 volt lamps represent about twenty per cent. more efficiency than the 100 volt lamps. That is found in practice. For instance the 100 volt lamps which are being supplied now by one of the large commercial manufacturers of lamps are six-tenths, or a fraction over six-tenths of an ampere and 100 volts; while the manufacturers of 50 volt lamps make a 50 watt lamp and get 50 volts out of the lamp and a better service for the time. I can tell of results that have been obtained by the Westinghouse Electric Company recently in the improvement of converters. They were manufacturing for a considerable time a converter that gave a leak of twelve one-hundredths on every 40 light converter and, recently, since certain analyses have been made of the iron and the quality of the iron has been improved and the method of annealing the iron has been improved, they have reduced that leakage from twelve to seven hundredths of an ampere, and the point that Dr. Duncan mentions that in putting in the alternating system they are able to take out the lamps in the service—certain circuits one gentleman said only about twelve per cent. of the total number of lamps burning on an average—I can state what is given here in New York in the service of the United states Illuminating Company. They are getting out of the total number of lamps wired on a circuit five and eight-tenths hours per lamp, which is about 23 per cent. All those points, I think, if taken into account will make the efficiency of the alternating current come much higher than would appear at first thought.

Mr. Tesla:—Another point of great importance is the fact that in the alternating system you have got an apparatus of almost ideal simplicity. If the armature burns out it is a matter of a few hours' work; and the repairs cost very little. If any part of the apparatus gives out it is easily replaced without trouble. With a direct current system, I think on the average out of 100 armatures, if you take them on a year's run, there will be about fifty that will have some trouble or other. The commutator will wear out in a few years, even with the best attention. I speak, of course, of the average.

The Chairman:—I think we are letting the subject wander a little from the efficiency of the alternating current apparatus. I think we had better keep to that subject.

Mr. Tesla:—I beg to remark on this that the title of the paper of Dr. Duncan was the tests on the efficiency of alternating current apparatus, and I never thought that the other subject would be mentioned. But Dr. Duncan's paper assumed the shape of a comparison of the efficiency and merits of the systems, and if I have wandered a little too far, I beg your pardon; it was not my fault, as the talk drifted in that direction.

Lieutenant John Millis:—I believe in all the alternating systems that are now in practical operation in this country the

rapidity of alternations, that is, the number per second, is practically the same. I would like to inquire what are the considerations which have determined this rate of alternations, whether they are mechanical or electrical, and if so, if Dr. Duncan can briefly explain to us what they are, also what the effect would be if the rapidity of alternations were varied. He touched lightly upon the theory of the effect that would be produced in the output or efficiency of the converter if the rapidity of alternations varied. I would like to ask if this theory has been confirmed by him, or to his knowledge by any one by practical experiment, and what the result of the experiment is.

DR. DUNCAN:—The rate of alternation is determined very greatly by the size of the unit in which the distribution is made. For large units a low rate is commonly employed. You will find in most of the continental and English systems that the rate of alternations has been decreased as the size of the converter has been increased. For a large converter a comparatively low rate should be used, and as in this country small converters have generally been employed, the rate is very much greater than where the converter has been large.

MR. TOWNSEND WOLCOTT:—Dr. Duncan referred to Prof. Ryan's paper and his idea in regard to diminishing the energy absorbed by hysteresis by vibrating the iron. Mr. Kennelly seemed to have the same idea as Prof. Ryan that you could get rid of the waste of energy very largely. The diagram of the hysteresis for one period as drawn by several experiments is as shown in Fig. 11 of Prof. Ryan's paper, one point at the bottom and the other at the top. Now, if you can come back by the same path as you go, of course, the energy is zero. But Mr. Swinburne divides the hysteresis into two kinds. He speaks of viscous hysteresis and ordinary hysteresis. Previous to the presentation of Prof. Ryan's paper I had the impression that the whole hysteresis worked in the manner which Mr. Swinburne calls viscous hysteresis; that is, like friction, it would resist in both directions. Mr. Swinburne's idea seems to be that the energy absorbed depends to a great extent upon the difference of phase between the magnetism in the iron and the magnetizing force of the current.

DR. MICHAEL I. PUPIN:—I would like to ask Dr. Duncan whether he knows of any experiments that have been made lately for the purpose of finding out how much of the lost energy is due to eddy currents and how much to magnetic hysteresis. As far as I am aware, there has been no experimental work of that kind done, and that has been spoken of as a work which it is very desirable to do—to determine the ratios between the two. I think that would also give us a means of testing whether work lost on account of magnetic hysteresis is the same for every period — whether they obtain the same current, as shown in the diagram referred to by Mr. Wolcott.

Dr. Duncan:—I am not prepared to give any figure on that point because I am experimenting on it at the present time. I am working now to weed out the eddy currents, and to determine the effect of hysteresis for different periods of reversal. There is no data at present to tell whether the loss on the iron is due to viscous or static hysteresis. If we go through the change in magnetic force at a very low speed then losses due to time hysteresis will not come in at all. If we go at a very high speed it will not come in at all. If we go at the present speed it will come in. As I say, at present my work is in trying to weed out the eddy currents. But I have not reached any results; and it is not a part of the paper. It is a very important question, though.

Mr. Leonard:—I take the liberty of speaking for a second on the question of a five hour load. I had been brought to select in the instance I noted the most exceptional one I knew of as being the future condition of supplying loss of all kinds. In New York City, which, of course, is the most exceptional in the other direction, the Edison station here has instead of five, nearer eight hours average load which, however, may be somewhat due to the advantages derived from the sale of motive power.

Mr. Justus B. Entz:—I would like to inquire if the losses due to eddy currents and hysteresis could not be determined by different thicknesses of discs. By taking two readings and separating them, I think it could be determined—the loss due to the eddy currents, of course, varying as the electromotive force. If the thickness of the disc is doubled the potential is doubled, while the resistance making a watt loss in each disc, varies as the cube, and if the disc in the converter were double in thickness and the same amount of iron, and the loss measured in the two cases, I should think they could be separated.

Mr. Tesla:—I should think, gentlemen, that if hysteresis is a distinct element in the loss of the converter it can be only so because it is intimately connected with the generation of the currents in the iron. We cannot go beyond a certain thickness of the iron—say number 38 or 40, which may be yet thick enough to give rise to the currents in the iron. But the results that Dr. Duncan has to-day brought out strengthened me in the idea which I always had, that ultimately the whole loss in the iron resolves itself into the loss due to the currents. The facts he finds show that the principal loss is due to the eddy currents. The loss in the iron is constant at all loads; on the other hand, he finds that the loss is proportioned to the square of the electromotive force, which would be precisely the case if the loss in the iron were due to eddy currents. I think that is an argument for this view.

Mr. Crosby:—It seems to me in that case that we want to know something of the subdivision of the iron, because by a very slight subdivision we might get the eddy current so predominating over the other effects that it might be when the subdivision were finished that they would appear as perhaps the

larger effects. I should like to ask Dr. Duncan what the cubic contents of the iron masses were whose total loss is given in the paper? It may have been stated, but I did not hear it.

DR. DUNCAN:—I think it is possibly in the paper. If not, it is somewhere else, and I would be very glad to give it to Mr. Crosby. As to distinguishing between the hysteresis and eddy currents with different thicknesses of plate, unfortunately Ewing has found that as far as this time hysteresis is concerned, it depends on the thickness of the plate independent of the eddy current. So, it would be impossible to distinguish in that way.

Adjourned.

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Electric Power Transmission. R. H. Smith. *Indust.; West. Elecn.*, Sept. 14, p. 149.

Machine Driving by Electricity. (Ill.) *Lond Elec. Engr.*, Sept. 6, p. 192.

Records by the Electric Launch "Eta." (Note.) *Lond. Elec. Engr.*, Sept. 20, p. 225.

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Electric Cars in Cleveland. *Elec. World*, Sept. 7, p. 169.

An Interesting Street Railway Motor Test at Asheville, N. C. *Elec. World*, Sept. 21, p. 201; *West. Elecn.*, Sept. 21, p. 163; *N. Y. Elec. Rev.*, Sept. 14, p. 10.

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Series Electrical Traction at Northfleet, England. E. Manville, Brit. Assn *Elec. World*, Sept. 28, p. 223; *Lond. Elec. Rev.*, Sept. 27, p. 351; *Lond. Elecn.*, Sept. 20, p. 506; *Lond. Elec. Engr.*, Sept. 20, p. 238.

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The John Stephenson Company Cars. (Ill.) *West. Elecn.*, Sept. 7. p. 135.

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Another Primary Battery. *West. Elecn.*, Sept. 28, p. 171. (Dr. E. D. Cross.)

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MECHANICAL.

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Reference List of Leading Authorities Cited in the Index of Current Electrical Literature.

NAME.	ABBREVIATION.	PUBLISHED, &c.
Engineer.	*Engr.*	London, 163 Strand, weekly. £1.9.
Engineering.	*Eng.*	London, 35–36 Bedford St. W. C.; weekly. £1.16.
Industries.	*Indust.*	358 Strand, London W. C. weekly. £1.12.
The Electrician.	*Lond. Elecn.*	London, 1 Salisbury Court, E. C.; weekly. £1.2.
The Telegraphic Journal and Electrical Review.	*Lond Elec. Rev.*	London, 22 Paternoster Row, E. C.; weekly. £1.1.8.
The Electrical Engineer	*Lond. Elec. Engr.*	London, 139–140 Salisbury Court; weekly, 17s. 4d.
Nature.	*Nat.*	London, 29 Bedford St., W. C.; weekly, £1.8.
The Electrical Engineer	*N. Y. Elec. Engr.*	New York, 150 Broadway; monthly, $3
The Electrical World.	*Elec. World.*	New York, 167–177 Times Building; weekly. $3
The Electrical Review.	*N. Y. Elec. Rev.*	New York, 13 Park Row; weekly. $3.
The Electric Age.	*Elec. Age.*	New York, 5 Dey Street; semi-monthly, $1.50.
Modern Light and Heat.	*Md Lt and Ht.*	Boston, 146 Franklin Street; weekly, $3.
Western Electrician.	*West. Elecn.*	Chicago, 6 Lakeside Building; weekly, $3.
Electric Power.	*Elec. P'wr.*	New York, 132 Nassau St. monthly, $3.
The Electro-Mechanic.	*Elec. Mech.*	Kansas City, Mo.; semi-monthly, $2.
Practical Electricity.	*Prac. Elec.*	Boston, 620 Atlantic Ave.; monthly, $2.
Journal of the Franklin Institute.	*Jour. Fkln. Inst.*	Philadelphia, Franklin Institute; monthly, $5.
Science.	*Science.*	New York, 47 Lafayette Place, weekly, $3.50.
Scientific American.	*Sci. Am.*	New York, 361 Broadway; weekly, $3.
Scientific American Supplement.	*Sci. Am. Supp.*	New York, 361 Broadway; weekly, $5.
Mechanics.	*Mech.*	Philadelphia, 907 Arch St.; monthly, $1.
Railroad Gazette.	*R'd. Gaz.*	New York, 73 Broadway; weekly, $4 20.
Street Railway Journal	*St. Ry. Jour.*	New York, 113 Liberty St.; monthly, $2
Street Railway Gazette.	*St. Ry. Gaz.*	Chicago, 9 Lakeside Building; monthly, $2.
Light, Heat and Power	*Lt. Ht. and Pr.*	Philadelphia, Drexel Building; weekly, $4.
Progressive Age.	*Prog. Age.*	New York, 18 Broadway; semi-monthly, $2.
Railroad and Engineering Journal.	*Rd. and Eng. Jour.*	New York, 45 Broadway; monthly, $3.

American Institute of Electrical Engineers.

LIST OF MEMBERS.

May 1st, 1890.

HONORARY MEMBERS.

Name.	Address.	Date of Membership.
Preece, Wm. H. *F. R. S.*	Electrician, General Post Office, London, Eng. Residence, Gothic Lodge, Wimbledon.	Oct. 21, 1884
Green, Dr. Norvin	(*Past President*). Pres't Western Union Telegraph Co., 195 Broadway, New York.	A April 15, 1884 M Oct. 21, 1884 H.M. Dec. 3, 1889

MEMBERS.

Acheson, Edw. G.	Electrician, Box 952, Pittsburgh, Pa.	A Jan. 3, 1888 M May 1, 1888
Ahearn, T.	Ahearn & Soper, Electrical Supplies, Ottawa, Ont.	A July 12, 1887 M Sept. 6, 1887
Anthony, Prof. W. A.	Consult'g Electrician. The Mather Electric Co., Manchester, Conn.	A Dec. 9, 1884 M Jan. 6, 1885
Batcheller, B. C.	Superintendent of the Pneumatic Dynamite Gun Co., 71 Broadway, New York.	A Sept. 6, 1887 M Nov. 1, 1887
Batchelor, Chas.	Electrical Engineer, 33 West Twenty-fifth St., New York.	A June 8, 1887 M July 12, 1887
Bates, J. H.	Box 2702, New York.	A Sept. 6, 1887 M Oct. 1, 1889
Bates, Maurice E.	Manager, Western Electric Construction Co., 503 Delaware St., Kansas City, Mo.	A Aug. 6, 1889 M Oct. 1, 1889
Bayly, B. *	Surveyor and District Engineer, Western District Colonial Gov't. Cape Town, Cape of Good Hope, Africa.	A Oct. 4, 1887 M Dec. 6. 1887
Bell, Prof. A. Graham	1336 Nineteenth St., Washington, D. C.	A April 15, 1884 M Oct. 21, 1884
Bernard, Edgar G.	Electrical Engineer, Utica, N. Y.	A Jan 5, 1886 M July 12, 1887
Birdsall, E. T. *M. E.*	Electrical Engineer, 115 Broadway, New York.	A June 8, 1887 M Nov. 1, 1887
Blake, Edward	Treasurer of New England Electric Co., 55 Oliver St., Boston, Mass.	A May 24, 1887 M Sept. 3. 1889

Name.	Addr ss.	Date of Membership.
BLAKE, FRANCIS	Auburndale, Mass.	A Sept. 3, 1889 M Oct. 1, 1889
BLODGETT, GEO. W.	Electrical Engineer B. & A. R. R. and Consulting Electrician, Boston, Mass	A July 12, 1887 M Sept. 6, 1887
BOSCH, ADAM	Sup't, Fire Alarm Telegraph. Newark N. J.	A April 15, 1884 M Jan. 6, 1885
BRADLEY, CHAS. S.	Electrical Engineer. Yonkers, N. Y.	A May 24, 1887 M Dec. 6, 1887
BROWN, JO. STANFORD	Electrical Engineer, with Daft Electric Light Co., 115 Broadway, New York.	A Sept. 6, 1887 M Nov. 1, 1887
BRUSH, CHAS. F.	Electrical Engineer. 956 Euclid Ave, Cleveland, O.	A April 15, 1884 M Oct. 21, 1884
BYLLESBY, HENRY M.	Vice-President and Gen'l Manager, Westinghouse Electric Co., Pittsburgh, Pa.	A Sept. 7, 1888 M Oct. 2, 1888
CARROLL, LEIGH	President and General Manager, The Edison Electric Illuminating Co., Birmingham, Ala	A Oct 1, 1889 M Nov. 12, 1889
CHAMBERLAIN, J. C.	Supt. Julien Electric Traction Co., 135 East Eighteenth St., New York.	A Dec. 6, 1887 M Jan. 3, 1888
CHEEVER, CHAS. A.	13 Park Row, New York.	A April 15, 1884 M Oct. 21, 1884
CHURCH, WM. LEE	Member of Westinghouse, Church, Kerr & Co., Engineers, 620 Atlantic Ave., Boston, Mass.	A April 5, 1887 M May 17, 1887
CLARK, ERNEST P.	Electrical Engineer, 192 Broadway, New York.	A Jan. 8, 1887 M Nov. 1, 1887
CLARKE, CHAS. L.	Mechanical and Electrical Engineer, 55 Liberty St., New York.	A April 15, 1884 M Jan. 6, 1885
COLBY, EDWARD A.	Electrician of the Weston Electrical Instrument Co., 606 High St., Newark, N. J.	A April 2, 1889 M May 7, 1889
CONANT, THOMAS P.	General Supt. of Construction, United Edison Mfg. Co., 65 Fifth Ave., New York.	A Nov. 1, 1887 M Jan. 3, 1888
ONDICT, G. HERBERT	General Manager, The Electric Car Co. of America, 4720 Green St., Germantown, Pa.	A July 12, 1887 M Sept. 6, 1887
COTHREN, WM. H.	Sup't of Wiring Department, Edison Electric Illuminating Co., 432 Fifth Ave., New York.	A Aug. 6, 1889 M Oct. 1, 1889
COWLES, ALFRED H.	Technical Adviser to the Cowles Smelting and Aluminum Co., Lockport, N. Y.	A Mar. 5, 1889 M May 7, 1889
CROCKER, FRANCIS B.	(*Manager*). Instructor in Electrical Engineering, School of Mines Columbia College, New York.	A May 24, 1887 M April 2, 1889
CROSS, CHAS. R.	Thayer Professor of Physics, and Director of the Rogers Laboratory, Mass. Institute of Technology, Boston, Mass.	A April 15, 1884 M Oct. 21, 1884
CUTTRISS, CHAS.	(*Manager*). Electrician, The Commercial Cable Co., 1 Broad St., New York.	A Nov. 1, 1887 M Dec. 6, 1887

Name.	Address.	Date of Membership.
DAFT, LEO	Electrician, Plainfield, N. J.	A Dec. 9, 1884 M Jan. 6, 1885
DANVERS, ALAN	Managing Director and Chief Electrician, The Anglo-Portugese Telephone Co., L't'd. 60 Travessa Santa Justa, Lisbon, Port'l.	A Nov. 1, 1887 M Sept. 3, 1889
DANVERS, ERNESTO	Electrical Engineer, Casilla 74, Rosario, Argentine Republic.	A Jan. 3, 1888 M May 1, 1888
DAVIES, JOHN E.	Professor of Physics, University of Wisconsin, 523 Carroll St. Madison, Wis	A Jan. 7, 1890 M Mar. 18, 1890
DELAFIELD, A. FLOYD, *Ph.D.*	Electrical Engineer, Noroton, Conn.	A May 7, 1889 M Oct. 1, 1889
DICKENSON, SAMUEL S.	Sup't, Commercial Cable Co., Hazel-Hill, Guysborough Co., N.S.	A Mar. 6, 1888 M Oct. 1, 1889
DIEHL, PHILIP	Inventor, Singer Sewing Machine Co., Elizabeth, N. J.	A April 15, 1884 M Dec. 9, 1884
D'INFREVILLE, GEORGES	Electrical Engineer and Expert 110 Liberty St., New York.	A Nov. 1, 1887 M Dec. 6, 1887
DOIJER, H.	34 Woburnsquare, W. C., London, Eng.	A Jan. 7, 1890 M Mar. 18, 1890
DUDLEY, CHARLES B.	Chemist and Scientific Expert, Penn. R. R. Co, 1219 Twelvth Ave., Altoona, Pa.	A Oct. 1, 1889 M Nov. 12, 1889
DUNCAN, DR. LOUIS	(*Vice-President*). Johns Hopkins University, Baltimore, Md.	A July 12, 1887 M Sept. 6, 1887
DYER, R. N.	Patent Attorney, 40 Wall St., New York.	A July 12, 1887 M Sept. 6, 1887
EDISON, THOMAS A.	Electrician and Inventor, Orange, N. J.	A April 15, 1884 M Oct. 21, 1884
FARNHAM, ISAIAH H.	Electrician for the N. E. Telephone & Telegraph Co., 50 Pearl St., Boston, Mass.	A June 8, 1887 M July 12, 1887
FIELD, C. J.	President and General Manager Field Engineering Co., 15 Cortlandt St., New York.	A June 8, 1887 M Nov. 1, 1887
FIELD, STEPHEN D.	Electrician and Inventor, Stockbridge, Mass.	A April 15, 1884 M Oct. 21, 1884
FITCH, D. H.	President, The Fitch Battery and Electric Co., Cazenovia, N. Y.	A Sept. 3, 1889 M Oct. 1, 1889
FLEMING, WILFRID H.	Care of Howard Fleming, Park Ave., Plainfield, N. J.	A Dec. 6, 1887 M Jan. 3, 1888
FOSTER, HORATIO A.	Electrical Engineer, 45 East Twenty-second St., New York.	A June 8, 1887 M Sept. 6, 1887
FREEMAN, DR. FRANK L.	Attorney-at-Law, Solicitor of Patents, Electrical Expert, 931 F St., Washington, D. C.	A May 7, 1889 M Sept. 3, 1889
GARRATT, ALLAN V.	Secretary and Treasurer of the National Electric Light Association, 18 Cortlandt St., New York.	A April 2, 1884 M May 7, 1889
GARVER, M. M.	48 Walnut St., Newark, N. J.	A July 10, 1888 M Sept. 3, 1889
GEYER, PROF. WM. E.	(*Manager*). Stevens Institute of Technology, Hoboken, N. J.	A June 5, 1888 M Sept. 7, 1888

Name.	Address.	Date of Membership.
GISBORNE, HARTLEY, *C. E.*	District Superintendent and Electrician, Government Telegraph Service of Canada, Qu'Appelle Station. Assa., N. W. Territory, Canada	A Dec. 9, 1884 M May 17, 1887
GRISCOM, WM. W.	Haverford College P. O., Montgomery Co., Pa. President, The Electro Dynamic Co., 224 Carter St., Philadelphia and Managing Electrician The Electrical Accumulator Co., New York.	A June 5, 1888 M Mar. 18, 1890
HALL, CLAYTON C.	Civil Engineer, 810 Park Ave., Baltimore, Md.	A April 15, 1884 M Oct. 21, 1884
HAMBLET, JAMES	Manager Time Service, W. U. Tel. Co., 195 Broadway, P. O. Box 3393, New York.	A Nov. 1, 1887 M Dec. 6, 1887
HAMILTON, GEO. A.	Electrician, Western Electric Co., 22 Thames cor. Greenwich St., New York.	A April 15, 1884 M Oct. 21, 1884
HAMMER, W. J.	Electrical Engineer, 23 Rowland St, Newark, N. J.	A June 8, 1887 M July 12, 1887
HANCOCK, WM. J.	Supt. of Telephones, Dept. of Public Works, Perth, Western Australia.	A Jan. 7, 1890 M Mar. 18, 1890
HASKINS, CHARLES H.	Electrician care of New York Club, Fifth Ave and Thirty-fifth St., New York.	A April 15, 1884 M Oct, 21, 1884
HAYES, HAMMOND V.	Electrician, American Bell Telephone Co. Boston, Mass. 127 Purchase St.. Cambridge. Mass.	A Nov. 12, 1889 M Mar. 18, 1890
HAYNES, F. T. J.	Divisional Telegraph Engineer, Great Western Railway, Taunton, Eng.	A Dec. 6, 1888 M Jan. 3, 1887
HAZARD, COL. ROWLAND R.	N. Y. District Railway Co., 120 Broadway, New York.	A April 15, 1884 M Oct. 21, 1884
HERING, CARL	Consulting Electrical Engineer, 3816 Spring Garden St, Philadelphia, Pa	A Jan. 3, 1888 M June 5, 1888
HERZOG, DR. F. BENEDICT	(*Manager*) President Herzog Teleseme Co., 30 Broad St., New York.	A May 24, 1887 M July 12, 1887
HIGGINS, EDWARD E.	Electrical Engineer, 202 Main St., Buffalo, N. Y.	A June 8, 1887 M July 12, 1887
HOUSTON, PROF. EDWIN J.	1521 Mt. Vernon St., Philadelphia, Pa.	A April 15, 1884 M Oct. 21, 1884
HOWELL, JOHN W.	(*Manager*). Electrician, Edison Lamp Co., Harrison N. J.	A July 12, 1887 M June 5, 1888
HOWELL, WILSON S.	Electrical Expert. Central Station, Edison Elec. Light Sysem, New Brunswick, N. J.	A Sept. 3, 1889 M Mar. 18, 1890
HUNTER, RUDOLPH M.	Mechanical and Elect'al Engineer, 926 Walnut St., Philadelphia, Pa	A July 13, 1886 M May 17, 1887
HYDE, JEROME W.	Springfield, Mass.	A June 8, 1887 M Nov. 1, 1887
JANNUS, FRANKLAND	Solicitor of Patents, 928-30 F. St Washington. D C.	A Nov. 12, 1889 M Mar. 18, 1890
JENKS, W. J.	Technical Department, United Edison Manufacturing Co., 44 Wall Street, New York.	A June 8, 1887 M Nov. 1, 1887

Name.	Address.	Date of Membership.
JOHNSON, E. H.	President, Sprague Electric Railway & Motor Co., 16 Broad St., New York.	A Feb. 7, 1888 M May 1, 1888
JONES, FRANCIS W.	Assistant Gen'l Manager and Electrician, Postal-Telegraph Cable Co., 187 Broadway, New York.	A April 15, 1884 M Oct. 21, 1884
KNOWLES, E. R.	Electrical Engineer, 430*a* Waverly Ave., Brooklyn, N. Y.	A June 8, 1887 M July 12, 1887
KNUDSON, A. A.	Electrican, 39 Nassau St., New York.	A Dec. 6, 1887 M Jan. 3, 1888
LANGE, PHILIP A.	Superintendent of Detail Department, Westinghouse Electric Co., Pittsburgh, Pa.	A Mar. 6, 1888 M June 5, 1888
LANGTON, JOHN	General Manager, Canadian Edison M'f'g Co., Sherbrooke, P. Q.	A Mar. 6, 1888 M June 5, 1888
LATTIG, J. W.	Sup't Telegraph, Lehigh Valley R. R., South Bethlehem, Pa	A June 8, 1887 M July 12, 1887
LEONARD, H. WARD	General Manager, United Edison Manufacturing Co., 65 Fifth Ave., New York.	A July 12, 1887 M Sept. 6, 1887
LEONARD, M. B.	Electrical Engineer, and Supt. of Telegraph, Chesapeake & Ohio R'y. Co., Richmond, Va.	A Nov. 6, 1886 M May 1, 1888
LIEB, JOHN W., JR.	Chief Engineer, Società Generale Italiana di Elettricita (Sistema Edison). Via S. Radigonda N. 4, Milan, Italy.	A Sept. 6, 1887 M Nov. 1, 1887
LOCKWOOD, THOMAS D.	(*Manager*). Electrical Engineer. and Advisory Electrician. P. O., Drawer 2, Boston, Mass.	A April 15, 1884 M Oct. 21, 1884
LYNE, LEWIS F.	Mechanical and Elect'al Engineer, 307 Grove St., Jersey City, N. J.	A Jan. 3, 1888 M June 5, 1888
MAILLOUX, C. O.	Consulting Electrical Engineer, 32 Liberty St., New York.	A April 15, 1884 M Oct. 21, 1884
MARKS, WILLIAM DENNIS,	*Ph. B., C. E.* Edison Electric Light Co., Philadelphia, Pa.	A Feb. 7, 1888 M May 1, 1888
MARSHALL, J. T.	Inspector of Lamp Manufacture, Edison Lamp Co., Harrison, N. J.	A Oct. 1, 1889 M Nov. 12, 1889
MAYNARD, GEO. C.	Electrical Engineer, 1409 New York Ave., Washington, D. C.	A April 15, 1884 M Dec. 9, 1888
MILLIS, JOHN	Lieutenant of Engineers, U. S. Army, P.O. Box 2128, New York.	A July 7, 1884 M Mar. 3, 1885
MILLS, FRANK P.	Superintendent Cleveland Iron Mining Co., Ishpeming, Mich.	A Jan. 6, 1885 M Mar. 3, 1885
NICHOLS, EDWARD L.	(*Vice-President*). Professor of Physics at Cornell University, Ithaca, N. Y.	A Oct. 4, 1887 M Dec. 6, 1887
PAINE, SIDNEY B.	Electrical Constructor, member of firm "Paine & Francis," 38 Pearl St., Boston, Mass.	A June 8, 1887 M Nov. 1, 1887
PARKS, C. WELLMAN	Electrician, 1825 Fifth Ave., Troy, N. Y	A July 12, 1887 M May 1, 1888

Name.	Address.	Date of Membership.
PARSHALL, H. F.	Electrician, Sprague Electric Railway & Motor Co., 16 Broad St., New York.	A Sept. 7, 1888 M Mar. 18, 1890
PATTEN, F. JARVIS.	Electrical Engineer, 47 Barclay St., Residence, 10 West Thirtieth St., New York.	A Sept. 6, 1887 M Nov. 1, 1888
PFANNKUCHE, GUSTAV	Engineer and Inventor, Cleveland, O.	A Feb. 7, 1888 M May 1, 1888
PICKERNELL, F. A.	Sup't. of Equipment, Amer. Tel. & Tel. Co., 18 Cortlandt St, N. Y.	A Feb. 7, 1890 M Mar. 18, 1890
POPE, FRANKLIN L.	(*Past President*). Expert for Westinghouse Electric Co., Elizabeth, N. J.	A April 15, 1884 M Oct. 21, 1884
PORTER, J. F.	403 N. 8th Street, St. Louis, Mo.	A Sept. 6, 1887 M Nov. 1, 1887
PRATT, J. HOWARD, JR.	Professor of Physics, Jacksonville, Ill.	A June 5, 1888 M Sept. 7, 1888
PRATT, ROBERT J.	Electrician. Manager, Electric M'f'g Co., Troy, N. Y.	A July 12, 1887 M Sept. 6, 1887
PRESCOTT, GEO. B., JR.	(*Manager*). Electrical Engineer, General Agent, Day's Kerite Wire and Cables. 16 Dey Street. New York.	A July 12, 1887 M Nov. 1, 1887
RAYMOND, CHAS. W. *	Civil and Electrical Engineer, 36 Dearborn St., Chicago, Ill.	A June 8, 1887 M May 17, 1887
RECKENZAUN, ANTHONY	Electrical Engineer, 7 Albert Terrace, Hemberton Road, Stockwell, London, S. W. England.	A Nov. 1, 1887 M Dec. 6, 1887
RECKENZAUN, FREDERICK,	Electrician, Box 225, West Hoboken, N. J.	A Mar. 6, 1888 M June 5, 1888
RICE, E. WILBUR, JR.	General Superintendent and Consulting Electrician, Thomson-Houston Elec. Co., Lynn, Mass	A Dec. 6, 1887 M Jan. 3, 1888
RIES, ELIAS E.	Electrician and Electrical Engineer, 430 South Broadway, Baltimore, Md.	A July 12, 1887 M Sept. 6, 1887
ROBERTS, E. P.	Electrician and Sup't, Swan Lamp Co., Belden St., Cleveland, O.	A Jan. 6, 1885 M Feb. 3, 1885
ROHRER, ALBERT L.	Electrical Engineer, with Thomson-Houston Electric Co., Lynn, Mass.	A Nov. 1, 1887 M May 1, 1888
SALOMONS, *Sir* DAVID LIONEL, *Bart. M. A.*,	Engineer and Barrister, Broomhill, Tunbridge Wells, Kent. and 49 Grosvenor St., London, W., England.	A Feb. 7, 1888 M May 1, 1888
SCHLESINGER, WM. M. **	Electrician of Schlesinger, Kimball & Co., Manufacturers of Electric Mining Machinery, 228 West Broad St., Columbus, O.	A Nov. 1, 1887 M Dec. 6, 1887
SCHULZE-BERGE, FRANZ	Edison Laboratory, Orange, N. J.	A Nov. 12, 1889 M Mar. 18, 1890
SHALLENBERGER, O. B.	Electrician, Westinghouse Electric Co., Pittsburgh, Pa.	A Sept. 7, 1888 M Dec. 4, 1888
SHEPARD, WM. E.	Electrician. Schuyler Elec. Light Co., 23 Pratt St., Middletown, Conn.	A Feb. 7, 1890 M Mar. 18, 1890
SLATER, HENRY B.	Electrical Engineer and Electro Metallurgist, Leadville, Col.	A April 15, 1884 M Dec. 9, 1884

Name.	Address.	Date of Membership.
SMITH, HERBERT G. *	General Electrician, Quezaltenango, Guatémala.	A Mar. 6, 1888 M June 5, 1888
STANDFORD, WILLIAM *	Ass't Sup't Telegraphs, Colonial Gov't, Cape Town, Cape of Good Hope, Africa.	A Oct. 4, 1887 M Dec. 6, 1887
STIERINGER, LUTHER	Electrical Expert, 44 Wall St., Room 71, New York.	A June 8, 1887 M Nov, 1, 1887
TERRY, CHARLES A.	Lawyer, Westinghouse Electric Co, Pittsburgh, Pa.	A April 5, 1887 M May 17, 1887
THOMPSON, EDWARD P.	Consulting Electrician and Patent Attorney in Electrical Cases, 5 Beekman St., New York.	A April 15, 1884 M Dec. 3, 1889
THURNAUER, ERNST	Chief Engineer, Thomson-Houston International Elec. Co, Michaelisbrücke, Hamburg, Germany.	A Oct. 14, 1887 M Dec. 6, 1887
TROWBRIDGE, PROF. W. P.	School of Mines, Columbia College, New York.	A April 15, 1884 M Oct. 21, 1884
TURNER, WILLIAM S.	Electrical Engineer, Woodbridge & Turner, 74 Cortlandt St., New York.	A Dec. 7, 1886 M Oct. 2, 1888
VAIL, J. H.	Electrical Engineer, Ass't to the Pres't, Sprague Electric Railway & Motor Co. 16 Broad St., New York.	A June 8 1887 M Nov. 1, 1887
VAN DEPOELE, CHARLES J.	Electrician, Electrical Railway Department, Thomson-Houston Electric Co., Lynn, Mass.	A June 5, 1888 M Sept. 7, 1888
VANSIZE, WILLIAM B.	Solicitor of Patents, 44 Broadway, New York.	A April 15, 1884 M Oct. 21, 1884
WADDELL, MONTGOMERY	Engineer, 18 Columbia Heights, Brooklyn, N. Y.	A Feb. 7, 1888 M May 1, 1888
WALKER, SYDNEY F.	Electrical Engineer, 195 Severn Road, Cardiff, England.	A June 2. 1885 M May 17, 1887
WALDO, DR. LEONARD *	Electrical Engineer, The Aluminum Brass & Bronze Co., Bridgeport, Conn.	A June 5, 1888 M Dec. 4, 1888
WEAVER, W. D.	Assistant Engineer, U. S. N., New York Navy Yard.	A May 17, 1887 M May 17, 1887
WEEKS, EDWIN R.	General Manager, Kansas City Electric Light Co., National Bank of Kansas City Building. Kansas City, Mo.	A Sept. 6, 1887 M Nov. 1, 1887
WESTON, EDWARD	(*Past President* and *Vice-President*). Electrician, 645 High St., Newark, N. J.	A April 15, 1884 M Oct. 21, 1884
WETZLER, JOSEPH	(*Manager*) Editor *Electrical Engineer*, 150 Broadway, N. Y.	A April 15, 1884 M Dec. 9, 1884
WHARTON, CHAS. J.	82 Bond St., London England.	A Jan. 3, 1888 M May 1, 1888
WHEELER, SCHUYLER S., *Sc.D.*	(*Manager*). President Crocker-Wheeler Electric Motor Co., 430-432 West Fourteenth St, Electrical Expert, Board of Electrical Control, 1266 Broadway, New York.	A June 2, 1885 M Sept. 1, 1885
WILKES, GILBERT	United Edison Mfg. Co., 65 5th Avenue, New York City.	A Jan. 7, 1890 M Mar. 18, 1890

Name.	Address.	Date of Election.
WILSON, FREMONT *	Electrician, 293 Lenox (6) Ave., New York.	A Mar. 6, 1888 M June 5, 1888
WINCHESTER, A. E.	Designer of Steam Electrical Plants, Wilton, Conn.	A June 8, 1887 M Nov. 1, 1887
WOODBRIDGE, J. L.	Electrical Engineer, Woodbridge & Turner, 74 Cortlandt St., New York,	A June 8, 1887 M Nov. 1, 1887
ZETSCHE, DR. CARL EDUARD,	Telegraph Engineer, N. Tieckstrasse 7, Dresden, Saxony.	A Nov. 1, 1887 M Jan. 3, 1888

Members, - - - 146.

ASSOCIATE MEMBERS.

Name.	Address.	Date of Election.
ABERNETHY, J. P.	Superintendent of Telegraph, 53 City Hall, Cleveland, O.	July 7, 1884
ANDERSON, ALEXANDER *	Superintendent and Manager of the Thomson-Houston Electric Co., Norfolk, Va.	Sept. 6, 1887
ANDREWS, WM. S.	Supt. Construction Dept, United Edison Mfg. Co., 65 5th Ave., New York.	Mar. 5, 1889
BACKSTROM, CHAS. A.	Manufacturer of Electric Incandescent Lamps, 154 & 156 West Twenty-seventh St., New York.	Nov. 13, 1888
BAILLARD, E. V.	124 West Sixty-first St, New York.	Dec. 3, 1889
BARTON, ENOS M.	President Western Electric Co., 227 South Clinton St., Chicago, Ill.	July 12, 1887
BARRETT, JOHN A.	Electrician, 189 Montague St., Brooklyn, N. Y.	June 8, 1887
BATES, D. H.	Vice-President and Gen'l Manager, The Electrical Accumulator Co., 44 Broadway, New York.	April 15, 1884
BAUER, A. H.	Electrical Engineer, Pullman Palace Car Co., Pullman Building, Chicago, Ill. Room 307.	*Feb. 7, 1890
BAUER, W. F.	Constructionist, The Electrical Accumulator Co., 62 Steuben St., East Orange. N. J.	April 15, 1890
BAYLES, ROBERT N.	Electrician, The "C & C" Electric Motor Co., 404 Greenwich St., New York.	Oct. 1, 1889
BEATTIE, JOHN, JR.	Manager and Superintendent, The Beattie Battery, Zinc and Electric Co., Fall River, Mass	Sept. 6, 1887
BELDING, WARREN S.	Electrician and Sup't. The Belding Motor and Mfg. Co., 6423 Stewart Boulevard, Englewood, Ill	April 15, 1890
BENBOW, WILLIAM C.	Thomson Houston Electric Co., 620 Atlantic Ave., Boston, Mass.	Dec. 3, 1889
BENNETT, J. C.	Electrician, United Edison Mfg. Co. 65 5th Avenue, New York.	Mar. 18, 1890
BERHGOLTZ, HERMAN	Mechanical Draughtsman, 161 East 34th St., New York City.	April 2, 1889
BERLINER, EMILE	Inventor, Columbia Road, between Fourteenth and Fifteenth Sts., Washington, D. C.	April 15, 1884

Name.	Address.	Date of Election.
BLACK, CHAS. N.	Student, Princeton Electrical School, Princeton, N. J.	Feb. 7, 1890
BLACKWELL, R. W.	Civil and Electrical Engineer, 27 Tenth Ave., New York.	July 7, 1884
BLAKE, HENRY W.	Agent, Sprague Electric Railway & Motor Co., 16 Broad St., New York.	Nov. 13, 1888
BLISS, DONALD M.	Electrician, The Canada Electric Co., Amherst, N. S.	Feb. 7, 1890
BLOOD, W. HENRY, JR.	Electrical Engineer, Thomson-Houston Electric Co., Lynn, Mass.	April 2, 1889
BOGART, A. LIVINGSTON	Electrical and Patent Expert, 22 Union Square. New York,	July 10, 1888
BOGUE, CHARLES J.	165 West Eighteenth St., New York,	Dec. 3, 1889
BOTTOMLEY, HARRY	Electrical Engineer, Thomson-Houston Electric Co., Lynn, Mass.	April 2. 1889
BOYNTON, EDWARD C.	Care of Elektron M'f'g Co., 79–81 Washington St, Brooklyn, N. Y.	Aug. 6, 1889
BRACKETT, PROF. CYRUS F.	Princeton, N. J.	April 15, 1889
BRADY, PAUL T.	Superintendent, Central N. Y. Telephone & Telegraph Co., Cooperstown, N. Y.	July 12, 1887
BRINER, C. J.	Vice-President, Central Electric Construction Co., 515 Walnut St., St. Louis, Mo.	April 2, 1889
BROPHY, WILLIAM	Inspector and Electrical Expert, The New England Insurance Exchange, Boston. Residence, 51 Salem St., Worcester, Mass.	Mar. 5, 1889
BROWN, ALEX. S.	General Manager, Morristown Electric Light, Heat & Power Co. Morristown. N. J.	Jan. 7, 1890
BROWN, ALFRED S.	Electrical Engineer, Western Union Telegraph Co, 195 Broadway, New York City.	Mar. 18, 1890
BROWN, CHARLES A.	Manager Western Electric Co., 227 South Clinton St., Chicago, Ill.	July 12, 1887
BROWNING, HOWARD L.	Promoter and Contractor, 41 Dey St., New York.	Dec. 6, 1887
BUCKINGHAM, CHAS. L.	Patent Attorney, Western Union Telegraph Co., 195 Broadway, New York.	April 15, 1884
BURNS, ELMER Z.	Consulting Electrical Engineer, Room 55, 4th Floor. 120 Broadway, N. Y.	Feb. 7, 1890
BUYS, BERT.	Electrician, Rutherford B. S. & C. Elec. Co., Rutherford, N. J.	Feb. 7, 1890
CARTY, J J.	Electrician, Metropolitan Telephone and Telegraph Co., 18 Cortlandt St., New York	April 15, 1890
CASE, WILLARD E.	6 Fort St., Auburn, N. Y.	Feb. 7, 1888
CHENEY, FREDERICK A.	Sec'y, Treas'r and General Manager, The Elmira Illuminating Co., Elmira, N. Y.	Oct. 1, 1889
CHERMONT, ANTONIO LEITE,	Manager Telephone Co. of Para, Para, U. S. of Brazil.	Mar. 18, 1890
CHILD, FRANK W.	Contractor and Builder of Electric Railways, 115 Broadway, New York.	July 10, 1888

Name.	Address.	Date of Election.
CHILDS, W. H.	Bookkeeper for The Esfey Organ Co., Brattleboro, Vt.	Sept. 6, 1887
CHINNOCK, C. E.	Edison United M'f'g Co., 65 Fifth Ave., New York.	April 15, 1884
CHUBBUCK, H. EUGENE	Electrician and Manager, Champion City Electric Light Co., Springfield, O.	Dec. 4, 1888
CHURCHILL, ARTHUR.	Electrical Expert, Frazar & Co., Yokohama, Japan.	April 15, 1890
CLEVELAND, WM. B.	Electrical Engineer, 309 Perry-Payne Building, Cleveland, O.	April 15, 1884
COFFIN, CHAS. A.	Vice-President and Treasurer, Thomson-Houston Electric Co., 620 Atlantic Ave., Boston, Mass.	Dec. 6, 1887
COLLINS, W. FORMAN **	Western Manager, *The Electrical Engineer*, 225 Dearborn St., Chicago, Ill.	Dec. 6, 1887
COMPTON, ALFRED G.	Professor of Physics, College of the City of New York, 17 Lexington Ave., New York.	Nov. 1, 1887
CORNELL, CHAS. L.	Electrical Engineer, Western Engineering Co., Kearney, Neb.	Feb. 7, 1890
CRANE, W. F. D.	Electrician and Mechanical Engineer, The Electric Car Co. of America, Twenty-third St. and Washington Ave., Philadelphia, Pa	Feb. 7, 1888
CROSBY, OSCAR T.	Electrical Engineer, Weems Electric Railway Co., Potter Building, New York.	Mar. 18, 1890
CURTIS, CHAS. G.	114 East Thirtieth St., New York.	April 15, 1884
CURTISS, GEORGE F.	Electrician, Thomson-Houston Electric Co., Lynn, Mass.	April 2, 1889
CUNTZ, JOHANNES H.	Assistant to Pres't Henry Morton, Stevens Institute of Technology, 137 Hudson St, Hoboken, N. J.	Mar. 5, 1889
CUSHMAN, HOLBROOK	Electrical Engineer, 337 West Twenty-second St., New York.	June 5, 1888
DANA, R. K.	Agent Washburn and Moen M'f'g Co., 16 Cliff St, New York.	April 15, 1884
DANFORTH, A. H. **	Great Falls, Montana.	July 12, 1887
DANIELL, FRANCIS G.	Care of Minneapolis Street Railway Co., Minneapolis, Mo.	Nov. 12, 1889
DAVENPORT, GEORGE W.	General Manager, Thomson-Houston International Electric Co, 620 Atlantic Ave., Boston, Mass.	June 4, 1889
DAVIDSON, EDW. C.	Patent Lawyer, Room 179, Times Bldg., New York.	Feb. 7, 1890
DAVIS, CHARLES H.	Consulting Electrical Engineer, 120 Broadway, New York.	Mar. 18, 1890
DAVIS, CHAS. M.	Superintendent, Light, Heat & Power Co, Pueblo Col.	July 12, 1887
DAVIS, DELAMORE L.	Superintendent, Salem Electric Light & Power Co., Salem, O.	April 2, 1889
DAVIS, JOSEPH P.	Consulting Engineer, Care of Phœnix Construction Co., 115 W. 38th St., New York City.	April 15, 1884
DAVIS, MINOR M.	Ass't Electrician, Postal Telegraph Cable Co, 5 Dey St, New York.	April 6, 1886

Name.	Address.	Date of Election.
DELANY, PATRICK BERNARD,	Inventor, 84 Broad St., New York.	April 15, 1884
DENTON, JAMES E.	Professor of Experimental Mechanics, Stevens Institute of Technology, Hoboken. N. J..	July 12, 1887
DICKERSON, E. N., JR.	Attorney-at-Law, 5 Beekman St., New York.	April 15, 1884
DION, ALFRED A.	Electrician, Intercolonial Railway, Moncton, N. B.	Jan. 7, 1890
DOANE, S. EVERETT	Thomson-Houston Electric Co., Swampscott, Mass.	Aug. 6, 1889
DOBBIE, ROBERT S.	Electrician, 1014 Bergen Ave., Jersey City, N. J.	Feb. 5, 1889
DOREMUS, CHARLES A.	*M. D. Ph. D.* Chemist and Physicist, Bellevue Hospital Medical College, College of the City of New York and American Veterinary College, 92 Lexington Ave., New York.	July 7, 1884
DURANT, GEO. F.	Vice-Pres't of Bell Telephone Co. of Mo., 322 Pine St., St. Louis, Mo.	April 15, 1884
ELEY, HARRIS H.	Electrical Workshop Sup't. W. C. & S. W Telephone Co., 88 Colston St., Bristol, Eng.	Jan. 7, 1890
ELMER, WILLIAM, JR.	Under-graduate in Electrical Engineering. Princeton University, Princeton, N. J.	Mar. 18, 1890
EMMET, HERMAN L. R.	Publisher and Printer, 36 Cortlandt St., New York.	April 15, 1884
ENTZ, JUSTUS B.	Electrical Engineer, 18 Columbia Heights, Brooklyn, N. Y.	Jan. 7, 1890
EUSTIS, HERBERT H.	President and Electrician, Eastern Electric Cable Co., 61 Hampshire St., Boston, Mass.	April 15, 1890
FARMER, PROF. MOSES G.	Electrician and Inventor, Eliot, Me.	April 15, 1884
FIELDING, FRANK E.	Chemist and Assayer, Virginia City, Nev.	Sept. 6, 1887
FISKE, HENRY G.	Electrician, Croton Magnetic Iron Mines. 45 East Twenty-second Street, New York	Nov. 12, 1889
FLACK, J. DAY	Ass't Electrician in charge of Tests, Edison Lamp Co., Harrison, N. J.	Dec. 6, 1887
FLEMING, WALTER M.	*M. D.* Vice-President of the Averell Insulating Conduit Co., 45 Broadway, Room 1, New York.	Jan. 3, 1888
FLOOD, J. F.	Electrician, Electric Light & Power Co., Steubenville, O.	Mar. 18, 1890
FORD, ELLSWORTH	Superintendent Edison Electric Light Co., Ottumwa, Ia.	July 12, 1887
FOX, JOHN M.	Electrician. United Edison Mfg. Co. 133 West 34th Street, New York.	Mar. 18, 1890
FREEDMAN, WILLIAM H.	Honorary Fellow in Electrical Engineering, Columbia College, 120 West 125th Street, New York.	Mar. 18, 1890
FULLER, LEVI K.	Vice-President, Estey Organ Co., Brattleboro, Vt.	Mar. 5, 1889
GILES, WALTER A	Electrical Engineer, Mill and Mine Elec. Equipment Co. Pittsburgh, Pa.	Nov. 1, 1887

Name.	Address.	Date of Election.
GILLILAND, E. T.	Vice-Pres't. Empire City Elec. Co., 15 Dey St. Residence, 179 West End Ave., New York.	April 15, 1884
GOLDMARK, CHAS. J.	473 Park Ave., New York.	June 5, 1888
GORTON, CHARLES	Belmont, N. Y.	Nov. 12, 1889
GRAY, W. N.	Manager, Branch Office, Mather Electric Co., Cincinnati, O.	Oct. 1, 1889
GROWER, GEORGE G.	Electrician and Chemist, Ansonia Brass and Copper Co., Ansonia, Conn.	Mar. 18, 1890
GRIFFIN, CAPT. EUGENE	Thomson-Houston Elec. Co., 620 Atlantic Ave., Boston, Mass.	Feb. 7, 1890
GUTMANN, LUDWIG	Electrical Engineer. P. O. Box 560, Pittsburgh, Pa.	Sept. 14, 1888
HALL, EDWIN H.	Assistant Professor of Physics, Harvard College, 5 Avon St., Cambridge, Mass.	Sept. 3, 1889
HARDING, H. McL.	Chicago, Ill.	May 24, 1887
HARVEY, WIRT B.	43½ Madison St., Memphis, Tenn.	Dec. 6, 1887
HASKINS, CARYL D.	Electrician, Thomson-Houston Electric Co., Lynn, Mass.	Mar. 18, 1890
HASSON, W. F. C.	Assistant Engineer. U. S. N. Instructor Johns Hopkins University. Baltimore, Md.	Mar. 18, 1890
HATZEL, J. C.	Electrical Engineer and Contractor, 29 West Twenty-sixth St., New York.	Sept. 3, 1889
HALSEY, WILLIAM B.	Inspector. Postal Telegraph-Cable Co., 94 Leonard St., New York.	Mar. 18, 1890
HEALY, CLARENCE L.	Sup't and Electrician, Commercial Telegram Co., 18 Broadway, New York.	April 15, 1884
HEBARD, GEORGE W.	Pres't. United States Electric Light Co., 120 Broadway, New York.	April 15, 1884
HENDERSON, ALBERT H.	Ries and Henderson, 45 Chamber of Commerce, Baltimore, Md.	July 12, 1887
HEILMAN, DONALD B.	Jonestown, Pa.	Mar. 18, 1890
HEINRICH, RICHARD O.	Demonstrator in Electrical Engineering and Physics. Lehigh University, South Bethlehem, Pa.	Oct 1, 1889
HENSHAW, FREDERICK V.	Assistant Electrician, The "C. & C." Electric Motor Co., 402 Greenwich St., New York.	Feb. 5, 1889
HOCHHAUSEN, WILLIAM	Electrician, The Excelsior Electric Co., 196 Willoughby St., Brooklyn, N. Y.	April 15, 1884
HOLT, MARMADUKE BURRELL,	Aspen Mining and Smelting Co., Aspen, Col.	April 15, 1890
HOPKINS, J. HERBERT	403 North 8th St., St. Louis, Mo.	April 2, 1889
HOWSON, HUBERT	Patent Lawyer, 38 Park Row, New York.	June 8, 1887
HUBRECHT, DR. H. F. R.	Director, Nederlandsche Bell Telephone Co., Amsterdam, Holland.	Oct. 4, 1887

Name.	Address.	Date of Election.
HUMPHREYS, C. J. R.	Manager, Lawrence Gas Co., Lawrence, Mass.	Sept. 6, 1887
HUTCHINSON, CARY T.	Edison Machine Works, Schenectady, N. Y.	Feb. 7, 1890
IDELL, FRANK E.	Mechanical Engineer, 41 Dey St., New York.	July 12, 1887
IHLDER, JOHN D.	Electrical Engineer, with Asterheld & Eickmeyer, Manuf'rs of Dynamos and Motors, Yonkers, N. Y.	Oct. 2, 1888
INSULL, SAMUEL	Electrical Manufacturer, 44 Wall St., New York.	Dec. 7, 1886
ISELIN, HENRY S.	President, Gibson Electric Co., 74 Cortlandt St., New York	June 2, 1885
IVES, EDWARD B.	Lieutenant U. S. A., Electrical Engineer, 47 Barclay St., Residence, One hundred and thirty-ninth St. and Grand Boulevard, New York.	April 2, 1889
IZARD, E. M.	Electrical Engineer, Secretary and Treas'r of the Leonard & Izard Co., The Rialto, Chicago, Ill.	Mar. 5, 1889
JACKSON, C. H.	President, United Electric Light and Power Co., 59 Liberty St., New York.	May 24, 1887
JACKSON, DUGALD C.	Sprague Electric Railway and Motor Co., 16 Broad St., New York.	May 3, 1887
JACKSON, FRANCIS E.	With Edison Lamp Co., Harrison, N. J.	Jan. 3, 1888
JAEGER, H. J. **	Chemical, Physical and Electrical Glass Blowing, 173 Pearl St., Brooklyn, N. Y.	July 12, 1887
JOHNSTON, W. J.	President, The W. J. Johnston Co., Ltd., Times Building, New York.	April 15, 1884
JONES, SEBASTIAN C. **	Electrical Engineer, Aurora, N. Y.	Sept. 6, 1887
JUDSON, WM. PIERSON,	U. S. Civil Engineer, Oswego, N. Y.	June 8, 1887
KENNELLY, A. E.	Electrician, Edison Laboratory, Orange, N. J.	May 1, 1888
KERR, THOMAS B.	Attorney-at-Law, 32 Nassau St., New York.	Nov. 1, 1887
KIMBALL, A. S.	Professor of Physics, Worcester Polytechnic Institute, Worcester, Mass.	Sept. 3, 1889
KINNEY, H. A.	Representative Brush Electric Co., N. Y. Life Ins. Building. Omaha, Neb.	Mar. 18, 1890
KNAPP, ALLAN C. *	Electrician, 225 Dearborn St., Chicago, Ill.	Sept. 6, 1887
KREIDLER, W. A.	Editor and Publisher, *Western Electrician*, 6 Lakeside Building, Chicago, Ill.	Oct. 4, 1887
LAIN, DAVID E., *B. S.*	Electrical Engineer, Yonkers, N. Y.	Nov. 13, 1888
LAW, M. D.	General Manager Consolidated Electric Light Co., Denver, Col.	Feb. 7, 1888
LAWSON, A. J.	Electrical Engineer and Contractor, Montreal, P. Q.	Mar. 18, 1890
LEDOUX, A. R.	Chemical Expert, 10 Cedar St., New York.	Dec. 7, 1886
LEE, HUNTINGTON	18 Cortlandt St., New York.	Dec. 3, 1889

Name.	Address.	Date of Election.
LEE, JOHN C.	Chemist and Electrician, American Bell Telephone Co., Brookline, Mass.	Mar. 18, 1890
LELAND, H. W. ***	Manager, Telephone Exchange, 259 Washington St , Jersey City, N J.	April 15, 1884
LEMP, HERMANN, JR.	Electrician, Thomson Electric Welding Co , Lynn, Mass.	April 2, 1889
LEWIS, HENRY FREDERICK WILLIAM.	General Manager and Secretary of the Western Counties South Wales Telephone Co., England, 16 High St , Bristol, Eng.	Mar. 5, 1889
LIEBIG, GUSTAV A., JR.	Elec'l Testing Bureau, Johns Hopkins University, Baltimore, Md.	Mar. 6, 1888
LOWREY, GROSVENOR P.	Lawyer, 15 Broad St., Residence 121 Madison Ave., New York.	Nov. 1, 1887
LUNDELL, ROBERT	Designing Draftsman, Sprague Elec. Ry. Co., 141 East 49th St., New York.	Feb. 7, 1890
MACLILIE, C. H. *	Broker in Electrical Securities, 11 Wall St., New York.	July 12, 1887
MAC QUESTEN, W. D. †	Field Engineering Co., 15 Cortlandt St., New York	April 15, 1890
MADDEN, O. E.	President, Empire City Electric Co., 15 Dey St., New York.	April 15, 1884
MAGEE, LOUIS J.	Electrical Engineer, in charge of European Office of Thomson-Houston International Electric Co., Michaelisbrücke 1, Hamburg, Gy.	April 2, 1889
MALCOLM, PHILIP S.	Western Agent, Gibson Electric Co., Portland, Oregon.	Mar. 18, 1890
MANSFIELD, GEO. W.	Electrical Engineer, with Thomson-Houston Electric Co., 620 Atlantic Ave., Boston, Mass.	June 2, 1885
MARTIN, T. COMMERFORD	(*Past President* and *Vice-President.*) Editor, *The Electrical Engineer*, 150 Broadway, New York.	April 15, 1884
MAVER, WILLIAM, JR.	(*Manager.*) Electrical Expert, 31 Nassau St., New York.	July 12, 1887
MCKIBBIN, GEORGE N.	Chemist and Electrician, 46 West Fifty-first St., New York.	June 8, 1887
MCKINSTRY, J. P.	185 Seneca St., Cleveland, O.	April 15, 1884
MCMAHAN, JOHN M. †	Bergen Point, N. J.	Aug. 6, 1889
MERCER, ANDREW G.	Treasurer and Electrician, Waterloo Electric Co., Waterloo, N. Y.	Sept. 3, 1889
MILLER, JOSEPH A.	Civil and Consulting Engineer, Providence, R. I	Dec. 9, 1884
MINER, W. M.	Electrician and Inventor, 89 East Second St., Plainfield, N. J.	July 12, 1887
MITCHELL, JOHN MURRAY	Lawyer, Box 3712, 45 Wall St., New York.	June 2, 1885
MITCHELL, SIDNEY Z.	Manager, Oregon, Washington and Idaho Agency, United Edison Mfg. Co., Washington Building, Portland, Or.	Nov. 12, 1889
MIX, EDGAR W.	Electrician, with Thomson-Houston Electric Co., Lynn, Mass.	Sept. 3, 1889
MOORE, JOHN J.	425 E. Twenty-fourth St , New York.	Nov. 12, 1889
MORRISON, J. FRANK	15 South St., Baltimore, Md.	April 15, 1884

Name.	Address.	Date of Election.
MORTON, HENRY, *Ph. D*	President of Stevens Institute of Technology, Hoboken, N. J.	May 24, 1887
MOSES, DR. OTTO A.	Electrician, 131 East Seventy-third St., New York.	May 17, 1887
MOSS. GEO. W.	Station Manager, C. & S. A. Tel. Co., Tehuantepec, Mexico.	Jan. 7, 1890
MOSSCROP, WM. A.	Sup't of Construction, Woodbridge & Turner, N. Y., Residence, 35 Clifton Place, Brooklyn, N. Y.	May 7, 1889
NEWELL, ARTHUR J.	Electrical Engineer, R. T. Oakes & Co., 184 Beech St., Holyoke, Mass.	Mar. 18, 1890
NICHOLLS, F. VICTOR *	Electrician and Manager Vancouver Electric Illuminating Co., Vancouver, B. C.	Dec. 4, 1888
NICHOLS, ARTHUR E.	Student in Electrical Engineering, Columbia College, 16 E. 35th St., New York City.	Mar 18, 1890
NUNN, RICHARD J., *M. D.*	Physician, 119 York St., Savannah Ga.	July 12, 1887
OATIS, JOHN X. *	Manager and Electrician, Amsterdam Electric Light & Power Co., Amsterdam, N. Y.	Sept. 7, 1888
OCKERSHAUSEN, H. A.	Electrical Engineer, 65 Madison Ave., Jersey City, N. J.	Sept. 6, 1887
O'DEA, M.	Electrician, University of Notre Dame, Notre Dame, Ind.	June 8, 1887
PALMER, G W., JR.	General Manager, McKeesport Light Co., McKeesport, Pa.	April 15, 1890
PARSELL, HENRY V., JR.	31 East Twenty-first St., New York.	Nov. 12, 1889
PAUL, CHAS. M.	Electrician, Care of Weston Electrical Instrument Co., 645 High St., Newark, N. J.	May 7, 1889
PECK, SAMUEL C.	Electrician, Thomson-Houston Electric Co., 620 Atlantic Ave, Boston, Mass.	Sept. 6, 1887
PEIRCE, WM. H.	Superintendent Marine Installations, United Edison M'f'g Co., 65 Fifth Ave., New York.	Sept. 7, 1888
PHELPS, GEO. M.	(*Treasurer*). Electrical Engineer and Editor, 150 Broadway, New York.	April 15, 1884
PHILLIPS, EUGENE F.	M'f'r Insulated Electric Wire, Providence, R. I.	July 13, 1889
PLUSH, DR. S. M.	Electrician, 319 South Tenth St, Philadelphia, Pa.	April 15, 1884
POOLE, CECIL P.	Contracting Electrical Engineer, 206-8 Eighth St. Lynchburg, Va.	Jan. 3, 1888
PUPIN, MICHAEL I.	Instructor in Mathematical Physics, Columbia College, 68 W. 72d St., New York City.	Mar. 18, 1890
POPE, RALPH W.	Secretary of the American Institute of Electrical Engineers, 5 Beekman St., New York.	June 2, 1885
RAE, FRANK B.	Electrical Engineer, Detroit Electrical Works, Detroit, Mich.	April 15, 1884
RANDALL, JOHN E.	Incandescent Lamp Dep't, Thomson-Houston Electric Co., Lynn, Mass.	May 7, 1889
REED, CHAS. J.	Electrician, 224 High St., Orange, N. J.	Mar. 5, 1889

Name.	Address.	Date of Election.
REED, HENRY A.	Secretary and Manager, Bishop Gutta-Percha Co., 422 East Twenty-fifth St., New York.	June 4, 1889
REILLY, JOHN C.	General Sup't, N. Y. & N. J. Tel. Co, 16 Smith St, Brooklyn, N. Y.	April 15, 1884
REINMANN, A. L.	Electrician, Breckenridge Ave., Pittsburgh, Pa.	June 8, 1887
RIKER, ANDREW L.	Electrical Engineer 15 East Fifty-fifth St., New York.	Nov. 1, 1887
ROBINSON, ALMON,	Draughtsman, Expert in Methods of Gearing, P. O. Box, 943, Lewiston, Me.	Sept. 6, 1887
ROEBLING, FERDINAND W.	Manufacturer of Electrical Wires and Cables, Trenton, N. J.	June 8, 1887
ROESSLER, S. W.	Captain, U. S. A., Willet's Point, Whitestone, N. Y.	
ROGERS, WINFIELD S.	Mechanical Engineer, Watervliet Arsenal, West Troy, N. Y.	Sept. 3, 1889
ROOME, H. C.	32 Liberty St., New York.	April 15, 1889
ROSENBAUM, WM. A.	Electrical and Patent Solicitor, Care of *The Electrical World*, Times Building, New York.	Jan. 3, 1889
ROYCE, FRED W.	Electrician and Patent Solicitor, 1408 Pennsylvania Ave., Washington D. C.	April 15, 1884
RYAN, HARRIS J.	Professor of Electrical Engineering, Cornell University, Ithaca, N. Y.	Oct. 4, 1887
SARGENT, W. D.	General Manager, N. Y. & N. J. Tel. Co., 16 Smith St., Brooklyn, N. Y.	April 15, 1884
SAWYER, FREDERICK J.	Pres't, The New England Electric Co., 55 Oliver St., Boston, Mass.	June 8, 1887
SAXELBY, FREDERICK,	Electrical Engineer, Superintendent of Exhausting Department, Edison Lamp Co., Harrison, N. J.	June 5, 1888.
SCHMIDT, FREDERICK,	Managing Director, The Schmidt-Douglas Electric Co., L'td., 31 Blenheim Rd., Bradford, England.	Jan. 3, 1888
SEARING, LEWIS	Care A. S. Pope, Box 124, Colorado Springs, Colorado.	April 3, 1888
SEELY, J. A.	General Manager, Complete Construction Co., 24 Cortlandt St., New York.	April 15, 1884
SERRELL, LEMUEL WM.	Mechanical and Electrical Engineer, 115 Broadway, New York.	Nov. 1, 1887
SHAW, GEORGE B.	General Manager, National Electric Mfg. Co., Eau Claire, Wis.	April 15, 1890
SHEEHAN, WILLIAM M.	Manager and Electrician, Newburgh Electric Light & Power Co., 65 Montgomery St., Newburgh, N.Y.	Sept. 3, 1889
SISE, CHARLES F.	Vice-President and Managing Director, Bell Telephone Co., of Canada, and Canadian Telephone Co., Ltd., Montreal, Canada	June 8, 1887
SMITH, FREDERICK H.	Civil Engineer. 227 East German St., Baltimore, Md.	Nov. 12, 1889
SMITH, GERRITT	Circuit Electrician, 195 Broadway, New York.	April 15, 1884

Name.	Address.	Date of Election.
SMITH, J. ELLIOT	Superintendent Fire Alarm Telegraph, 157 East Sixty-seventh St., New York.	April 15, 1880
SMITH, JESSE M.	Consulting Electrical Engineer and Expert in Patent Causes, 36 Moffatt Block, Detroit, Mich.	April 15, 1884
SOUZA, CARLOS MONTEIRO e	Rio de Janeiro, Brazil.	Sept. 6, 1887
SPICER, CHAS. W. W.	122 West 21st. St., New York City.	Nov. 12, 1889
SPIKE, CLARENCE J.	Halifax, N. S.	Mar. 18, 1890
SPRAGUE, FRANK J.	Electrician, and Vice-President, Sprague Electric Railway & Motor Co., 16 Broad St., New York.	May 24, 1887
STADELMAN, WM. A.	Vice-Prest. and Chief Engineer, Equitable Elec. Ry. Construction Co., 418 Walnut St., Philadelphia, Pa.	Feb. 7, 1890
STANLEY, WILLIAM, JR.	Electrician, Englewood, N. J.	Dec. 6, 1887
STEARNS, CHARLES K.	With Thomson-Houston Electric Co., 620 Atlantic Ave., Boston, Mass.	Aug. 6, 1889
STEBBINS, THEODORE	Electric Railway Inspector, Thomson-Houston Elec. Co, 620 Atlantic Ave., Boston, Mass.	July 9, 1889
STEINMETZ, CHARLES	Electrician, Osterheld & Eickemeyer, Yonkers, N. Y.	Mar. 18, 1890
STOCKBRIDGE, GEO. H.	Patent Attorney, 132 Nassau St., New York.	May 24, 1887
STOCKLY, GEO. W.	President, Brush Electric Co., Cleveland, O.	April 15, 1884
STUART, OTIS K.	Clerk, Thomson Electric Welding Co., Lynn, Mass.	June 4, 1889
STUMP, CLARENCE E.	Bus. M'g'r and Treas'r, The W. J. Johnston Co., Ltd., Publishers of the *Electrical World*, 167–177 Times Building, New York.	May 17, 1887
TAYLOR, CHARLES	Metallurgist, U. S. Assay Office, 30 Wall St., New York.	Nov. 1, 1887
TEMPLE, WILLIAM CHASE	Electrical Engineer, 575 Madison Ave., New York.	May 3, 1887
TESLA, NIKOLA	Electrical Engineer and Inventor, Astor House, New York.	June 5, 1888
THOMPSON, WILLIAM GEO.	MACNEILL, Resident Engineer, Sault Ste. Marie Canal, Sault Ste. Marie, Ontario.	July 12, 1887
THOMSON, PROF. ELIHU	(*President*). Electrician, Thomson-Houston Electric Co., and Thomson Electric Welding Co., Lynn, Mass.	April 15, 1884
TOWNSEND, HENRY C.	(*Manager*). Attorney and Expert in Electrical Cases, 5 Beekman St., New York.	July 10, 1888
TREGONING, JOHN	Sup't, Thomson Electric Welding Co., 325 Boston St., Lynn, Mass.	April 2, 1889
UEBELACKER, CHAS. F.	Student, Princeton Electrical School. Princeton, N. J.	Feb. 7, 1890
UHLENHAUT, FRITZ, JR.	Field Engineering Co., 15 Cortlandt St., New York.	May 7, 1889

Name.	Address.	Date of Election.
UPTON, FRANCIS R.	(*Vice-President*). Treasurer and General Manager, Edison Lamp Co., Harrison, N. J.	May 17, 1887
VAIL, THEO. N.	President, Metropolitan Telephone & Telegraph Co., 18 Cortlandt St, New York.	April 15, 1884
VARLEY, RICHARD, JR.	Electrician, Okonite Insulated Wire Co., Passaic, N. J.	Mar. 18, 1890
VAN BRUNT, WALTER	Manager, Duluth Telephone Co., Duluth, Minn.	Sept. 6, 1887
VANCE, A. ST. CLAIR	65 Fifth Avenue, New York.	April 2, 1889
VAN TRUMP, C. REGINALD	Wilmington City Electric Co., Wilmington, Del.	Feb. 5, 1889
VAN VALKENBURGH, F. S.	Central and South American Tel. Co, Tehuantepec, Mexico.	June 5, 1886
VAN VLECK, FRANK	Chief Engineer, San Diego Cable Tramway Co., San Diego, Cal.	Nov. 16, 1886
VIDUARRE, JOSE	Dealer in Electrical Supplies, Ponce, Porto Rico.	Sept. 6, 1887
WACKER, GEORGE G.	Electric Organs, 3644 Third Ave., New York.	Sept. 6, 1887
WALLACE, WILLIAM	Wire Manufacturer, Ansonia, Conn.	April 15, 1884
WALTER, HENRY E.	Schenectady, N. Y.	April 2, 1889
WARDELL, GEORGE P.	19 Cedar St., Newark, N. J.	Nov. 12, 1889
WARING, RICHARD S.	205 Penn Building, Pittsburgh, Pa.	April 15. 1884
WATERHOUSE, FRANK G.	Ass't General Sup't, Westinghouse Electric Co., Pittsburgh, Pa.	Sept. 6, 1887
WATERS, EDWARD G.	Electrical Engineer. Thomson-Houston Electric Co, 620 Atlantic Ave., Boston, Mass.	Mar. 18, 1890
WEIL, LEOPOLD	Importer, 121 Mercer St., New York.	June 8, 1887
WELLES, FRANCIS R.	Manufacturer, Bell Telephone Manufacturing Co., Antwerp, Belgium	Sept. 6, 1887
WHITE, H. C.	Manager, Phœnix Iron Works Co., 16 Dey St., New York.	April 15, 1884
WHITE, J. G.	Manager, The Western Engineering Co., Kearney, Neb.	April 2, 1889
WHITE, WILL F.	Electrical Engineer, Sec'y and Treas. Western Engineering Co., Kearney, Neb.	Feb. 7, 1890
WHITMORE, W. G.	Electrical Engineer, United Edison Mfg. Co., 65 Fifth Ave., N. Y. C.	Mar. 18, 1890
WHITNEY, HENRY M.	President, West End Street Railway Co., 81 Milk St., Boston, Mass.	July 12, 1887
WIGHTMAN, MERLE J.	Electrical Engineer and Inventor, Thomson-Houston Electric Co., Lynn, Mass.	Mar. 5, 1889
WILEY, WM. H.	Scientific Expert, 15 Astor Place, New York.	Feb. 7, 1888
WILLIAMS, CHARLES, JR.	Electrician, 100 Sudbury St., Boston, Mass.	April 15, 1884
WILLIAMS, JAMES B. *M. D.*	44 Broadway, New York.	Sept. 7, 1888
WINKLER, CHARLES F.	Electrician, Troy Electric Dynamo Co., 4 Park Ave., Troy, N. Y.	Sept. 3, 1889
WINSLOW, I. E.	458 Produce Exchange, New York.	Nov. 12, 1889

Name.	Address.	Date of Election.
WINTRINGHAM, J. P.	Theorist, 36 Pine St., New York.	May 7, 1889
WIRT, CHARLES.	United Edison Mfg. Co., 65 5th Ave., New York.	Sept. 8, 1888
WOLCOTT, TOWNSEND	Consulting Electrician, 849 Greene Ave., Brooklyn, N. Y.	Mar. 6, 1888
WOLVERTON, B C.	Electrician, N. Y. & Pa. Telephone & Telegraph Co., Elmira, N. Y.	Mar. 18, 1890
WOOD, E. J.	Consulting Engineer and Contractor, 243 Broadway, New York.	July 12, 1887
WOODRUFF, H. O.	Agent, Sprague Electric Railway & Motor Co., Des Moines, Iowa.	Oct. 2, 1888
WORTHINGTON, GEORGE	Manager, *Electrical Review*, 13 Park Row, New York	April 15, 1884
YOUNG, ALDEN M.	Contractor for Organization and complete Equipment of Electric Lighting Plants, 101 Bank St., Waterbury, Conn.	Sept. 6, 1887
YOUNG, C. GRIFFITH	Superintendent and Electrician, Mount Morris Electric Co., Vandam and Greenwich Sts. Residence, 262 West One hundred and twenty-third St., New York.	Jan. 3, 1889
ZALINSKI, EDMUND L. *	Captain of Artillery, U. S. A., Care of War Dept., Washington, D. C.	May 17, 1887

Associate Members, - - - 280.

SUMMARY.

Honorary Members, - - - - - - - - -	2
Members, - - - - - - - - - - -	145
Associate Members. - - - - - - - - -	280
Total - - - - -	427

Any errors in this list, or changes in address should be reported to the Secretary.

OTHO ERNEST MICHAELIS, Ph. D., Major of Ordnance, U. S. Army, and Commandant of the Kennebec Arsenal, Augusta, Me., died at Augusta, of spinal menginitis, May 1st, 1890. Major Michaelis—then Captain—was elected an Associate Member of the Institute December 9th, 1884, and was transferred to full membership, January 6th, 1885. On May 18th, 1886 he was elected a Manager, and upon the expiration of his term was elected a Vice-President May 21st, 1889, which office he held at the date of his death. He was 46 years of age.

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JO. STANFORD BROWN, GEORGES D'INFREVILLE, GEORGE H. STOCKBRIDGE. } Library

Committee on Membership, etc.

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PROF. W. A. ANTHONY, " " Manchester, Ct.
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JOSEPH WETZLER, New York,
GEO. B. PRESCOTT, JR., New York.

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T. COMMERFORD MARTIN, DR. F. BENEDICT HERZOG.

Committee on Papers and Meetings.

T. C. MARTIN, New York, GEORGE M. PHELPS, New York, JOHN W. HOWELL, Harrison, N.J., HUBERT HOWSON, New York, DR. SCHUYLER S. WHEELER, New York.

Transactions of the Institute Already Published.

Vol. 1, 1884. (Out of Print.)

HISTORICAL PREFACE. NOTES ON PHENOMENA IN INCANDESCENT LAMPS.—(Illustrated.) Prof. Edwin J. Houston of Philadelphia.—UNDERGROUND WIRES. (Illustrated.) W. M. Callender of New York.—SYNCHRONISM (Illustrated.) Prof. Edwin J. Houston of Philadelphia.—THE DELANY SYNCHRONOUS MULTIPLEX SYSTEM OF TELEGRAPHY. (Illustrated.) Prof. Edwin J. Houston of Philadelphia.—THE SCIENTIFIC CITY STREET. (Illustrated.) Col. Rowland R. Hazard of New York.—AN EXPERIMENTAL METHOD OF STUDYING THE DYNAMO MACHINE. By Prof. C. F. Brackett, of Princeton, N. J.—EARTH WIRES; OR, THE EARTH AS AN ELECTRIC CIRCUIT COMPLETER. Thomas D. Lockwood, Boston, Mass.—TELEGRAPHING WITHOUT WIRES—AN EXPERIMENT. (Illustrated.) S. J. M. Bear.—CHEMISTRY OF THE CARBON FILAMENT. Edward P. Thompson, of New York.—DEPOSITING VATS IN "SERIES." H. B. Slater, now of Leadville, Col.—THE PATENT OFFICE; ITS RELATION TO INVENTORS AND ITS NEEDS. C. J. Kintner, now of New York.

Vol. II, 1885.

THE PROTECTION OF ELECTRICAL INVENTIONS. F. Jannus, of Washington, D. C.—COST OF MINE LIGHTING. Frank P. Mills, now of Ishpeming, Mich.—THE ELECTRIC ARC LAMP FRICTIONAL CLUTCH. (Illustrated.) By Edward P. Thompson of New York.—DESCRIPTION OF A LARGE SECONDARY BATTERY PLANT FOR GENERAL COMMERCIAL DISTRIBUTION. E. P. Roberts, of Cleveland, O.—DELANY'S SYSTEM OF FAC-SIMILE TELEGRAPHY. (Illustrated.) Prof. Edwin J. Houston of Philadelphia.

Vol. III, 1886. (Out of Print.)

UNDERGROUND ELECTRICAL SYSTEMS. By Sidney F. Shelbourne.—THE GREAT TANGENT GALVANOMETER OF THE CORNELL UNIVERSITY. Prof. W. A. Anthony, now of Manchester, Conn.—SOME RECENT ADVANCES IN TELEPHONY. (Illustrated.) Thomas D. Lockwood, of Boston, Mass.—THE PATENT OFFICE AND PATENT OFFICE PRACTICE. A. C. Fowler, of New York.—STATIC DIFFICULTIES IN TELEGRAPH WIRES. F. W. Jones of New York. Containing a Synopsis, with reference to 113 American and Foreign Patents for Inventions intended to overcome these difficulties.—SECONDARY BATTERIES FOR LIGHT AND POWER. A. H. Bauer.—THE WIRE GAUGE. Report of Committee.—NOTES ON DYNAMIC INDUCTION. Sidney F. Shelbourne.

Vol. IV, 1887. (Out of Print.)

ELECTRIC STREET CARS. T. C. Martin, of New York.—THE PRACTICAL REQUIREMENTS OF SMALL MOTORS. S. S. Wheeler, of New York.—DISTRIBUTION OF ELECTRICITY BY SECONDARY GENERATORS. Discussion by F. L. Pope, Dr. Otto A. Moses, Captain O. E. Michaelis, Prof. Elihu Thomson and others.—STORAGE BATTERIES IN PRACTICE. E. P. Roberts, of Cleveland, O.—DIFFERING TEMPERATURE COEFFICIENTS OF THE DIFFERENT COILS OF A FINE RHEOSTAT. Prof. W. A. Anthony, now of Manchester, Conn.—ON THE BEST RATIO OF THE SECTION OF THE GRAMME ARMATURE TO THE SECTION OF THE FIELD MAGNETS. (Illustrated.) Dugald C. Jackson, now of Lincoln, Neb.—NOVEL PHENOMENA OF ALTERNATING CURRENTS. (Illustrated.) Prof. Elihu Thomson, of Lynn, Mass.—A FEW COMPARATIVE STATISTICS OF ELECTRIC RAILWAYS. T. C. Martin, of New York. (With tabular statement.)—CENTRAL STATION CONSTRUCTION. J. A. Powers, of Troy, New York.—ON THE CHANGE FROM NEGATIVE TO POSITIVE OF THE TEMPERA

TURE COEFFICIENTS OF SOME CARBON FILAMENTS. (Illustrated.) Prof. W. A. Anthony, of Manchester, Conn.—LEAD ENCASED CONDUCTORS. (Illustrated.) David Brooks, of Philadelphia.—THE ELECTRIC LIGHTING OF PASSENGER TRAINS. (Illustrated.) Geo. W. Blodgett, of Boston.

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